Ensemble Postprocessor (EnsPost) User's Manual

HEFS Release 0.3.2
Last updated: April 9, 2013

National Weather Service
Office of Hydrologic Development

Contents

1 Overview

This section is pending transition of HEFS from beta-testing to operational use, and will be supplied at a later date. Once completed, it is anticipated that this section will provide an overview of the user's manual.

1.1 EnsPost Software Components

The EnsPost software consists of the parameter estimator, the EnsPostPE, and the ensemble generator, the EnsPost. The EnsPostPE estimates the parameter and calculates the error statistics, whereas, the EnsPost post-processes the ensemble members of the model forecast over the forecast horizon. Figure 1 shows the schematic of the EnsPost components.

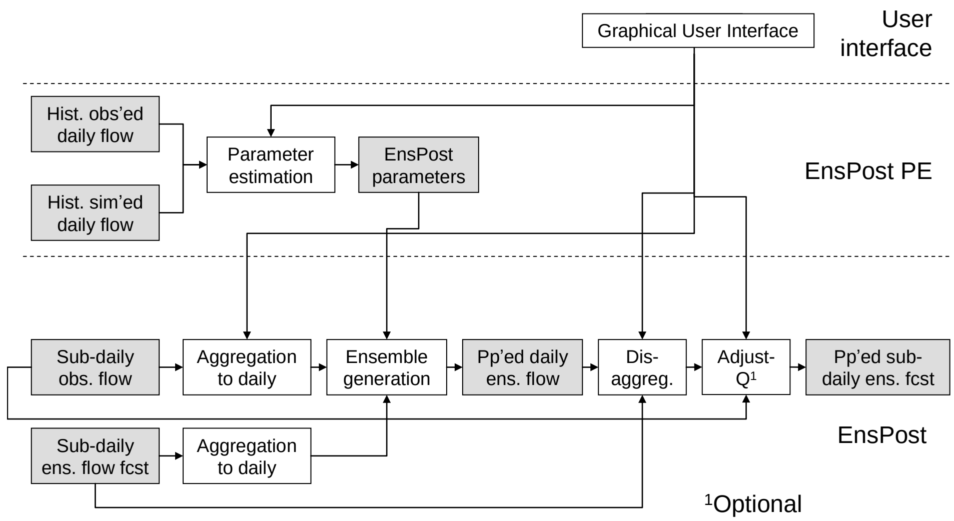


Figure 1: Schematic of the EnsPost components

1.2 Terminology

The following terminology is used throughout this manual.

1.2.1 Scientific Terms

1.2.2 Software Terms

- *CHPS locationId*: The locationId used in the CHPS configuration files to specify a location.
- *CHPS parameterId*: The parameterId used in the CHPS configuration files to specify a data type. Common parameterIds are as follows:
  - *EnsPost location*: A location for which the EnsPost is to be executed and parameter estimated. An EnsPost location is defined by a CHPS locationId and parameterId and will sometimes be referred to by its *identifier* within this manual, which is "<locationId> (<parameterId>)". For example "NFDC1HUF (MAP)".
  - *parameter zip group*: A group of locations for which the EnsPost will be executed at one time (via one model adapter execution) and, therefore, for which the estimated parameters must be zipped together.

1.3 Notation

The following notation is used:

- Important terms are displayed in *italics* the first time they are used and defined.
- Graphics user interface components are displayed in **Bold**.
- List items, such as available plug-ins or allowed parameter settings, will be in “quotes”.
- Parameter names are displayed as normal text.
- Text which is to be entered at a command line or into an ASCII text file (including XML files) is denoted in `courier font`.

1.4 Manual Layout

This document follows this outline:

Section **Error! Reference source not found.**: A description of the science underlying EnsPost

Section **Error! Reference source not found.**: A reference for all of the components and the bells and whistles of the EnsPostPE.

Section **Error! Reference source not found.**: A description of how to execute the EnsPost operationally to post-process stream flow ensembles and configuration reference manuals model adapters.

2 Science of EnsPost

2.1 Introduction

The Hydrologic Ensemble Forecast System (HEFS) produces ensemble streamflow forecasts out to a year into the future. Unlike a single-valued, or deterministic, forecast, an ensemble forecast provides an estimate of the forecast uncertainty, i.e., predictive uncertainty. Such an ensemble forecast, from which various probabilistic forecasts may be derived, should account for various sources of uncertainty in the forecast process. Toward that end, it is useful to examine briefly how hydrologic forecasting is done at the River Forecast Centers (RFC).

A collection of hydrologic models (i.e., SAC, SNOW-17, etc.) is supplied with a forecast of the input forcings, the initial conditions, and, if available, recently observed flow, and run over a specific forecast horizon. The hydrologic models solve many (complex) equations that approximate the various, generally nonlinear processes between the forcing variables, i.e., the input, and streamflow, i.e., the output. This output contains uncertainties propagated from those in the input forcing forecast, initial conditions, hydrologic model parameters and structures, and observations of flow, and other variables. Because of the complex, multiscale, nonlinear dynamics involved, it is not an easy task, if at all feasible, to isolate uncertainty contributions from among the different sources.

Broadly, these uncertainties may be grouped into two categories, input uncertainty and hydrologic uncertainty. The former comprises uncertainties in the forecast of the input variables to hydrologic models, such as precipitation and temperature. The latter comprises uncertainties in the initial conditions, parameters and structures of the hydrologic models, and those due to human influences such as flow regulations. As part of the HEFS, the forecast input uncertainties are modeled by the Meteorological Ensemble Forecast Processor (MEFP), whereas hydrologic uncertainty is modeled by the hydrologic ensemble post-processor, EnsPost. Figure 2 illustrates how the input and hydrologic uncertainties, as represented by ensembles, are propagated and integrated to represent the total uncertainty.

2.2 Methodology

A number of different ensemble post-processing techniques have been developed to model the hydrologic uncertainty. There are, however, only a few that have demonstrated applicability in an operational environment. The technique developed at the Office of Hydrologic Development (OHD) is named EnsPost. EnsPost was developed with the intention of being simple, parsimonious (in the sense that it involves a minimal number of parameters), relatively easy to understand, and not very computing resource-intensive. Similarly to any other statistical technique, however, EnsPost requires a long period of record to estimate the parameters reliably. Because the technique is designed to model the hydrologic uncertainty only, EnsPost uses simulated (i.e. forecast streamflow with perfect future input forcing) rather than forecast streamflow (see Figure 2).

In the context of streamflow simulation, quantifying hydrologic uncertainty amounts to quantifying the error in the model simulated flow relative to the verifying observed flow. The magnitude of this error usually depends on that of the simulated flow. When this error is added to the simulated flow, the sum represents the error-corrected flow. Hence, if this error is modeled as an uncertain, or random, variable, the sum of this random error and the simulated flow represents the simulated flow that reflects hydrologic uncertainty. In general, the statistical properties of this error depend on the magnitude of the simulated flow. As such, one may consider EnsPost as estimating the conditional probability distribution of observed flow (i.e. the error plus the simulated flow) given the simulated streamflow (see Figure 3b).

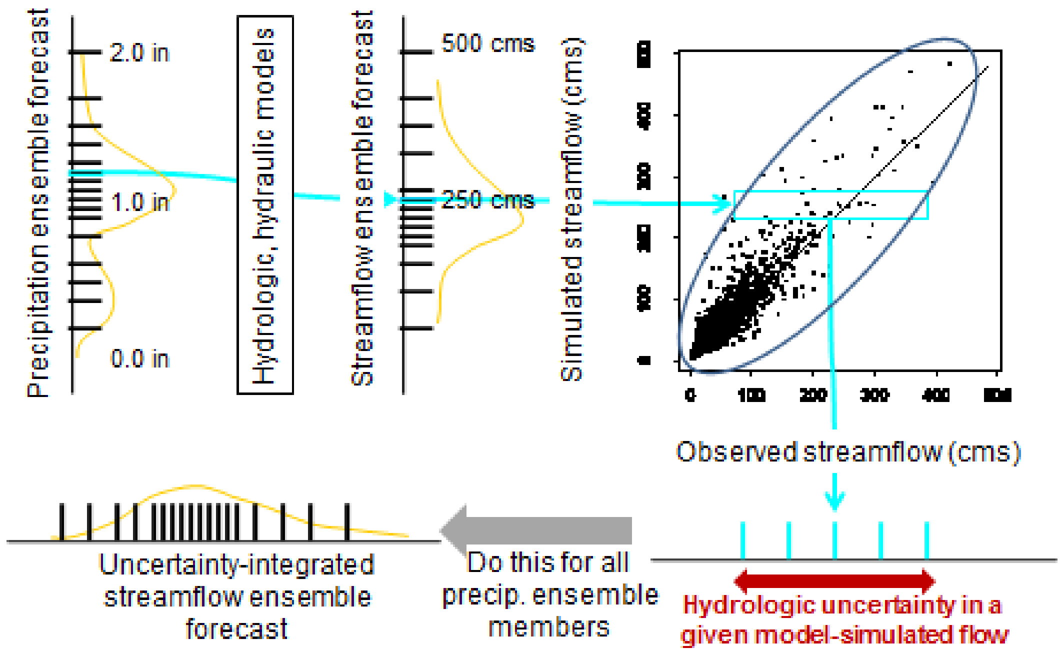


Figure 2: Illustration of integration of input and hydrologic uncertainties in hydrologic ensemble forecasting

The conditional distribution of observed flow may be estimated from the joint distribution of the observed and simulated streamflows. There are a number of different ways to estimate the joint distribution (e.g., Krzysztofowicz, 1999, Montanari and Brath, 2004, Seo et al., 2006, Chen and Yu, 2007, Hantush and Kalin, 2008, Montanari and Gross, 2008, Todini, 2008, Bogner and Pappenberger, 2011, Brown and Seo, 2012). It is well-known that variables such as precipitation and streamflow are, in general, skewed. This makes modeling of the joint distribution rather difficult. For that reason, in EnsPost, these variables are normal-transformed so that the transformed variables are individually normal. Such transformation is referred to as Normal Quantile Transform (NQT). Figure 3a illustrates NQT for observed and simulated flows in which the scatter plot in the upper-left corner represents the scatter plot in the upper-right corner of Figure 2 (but with x- and y-axis reversed). The NQT is popular and has been widely used in hydrologic and related applications over the years.

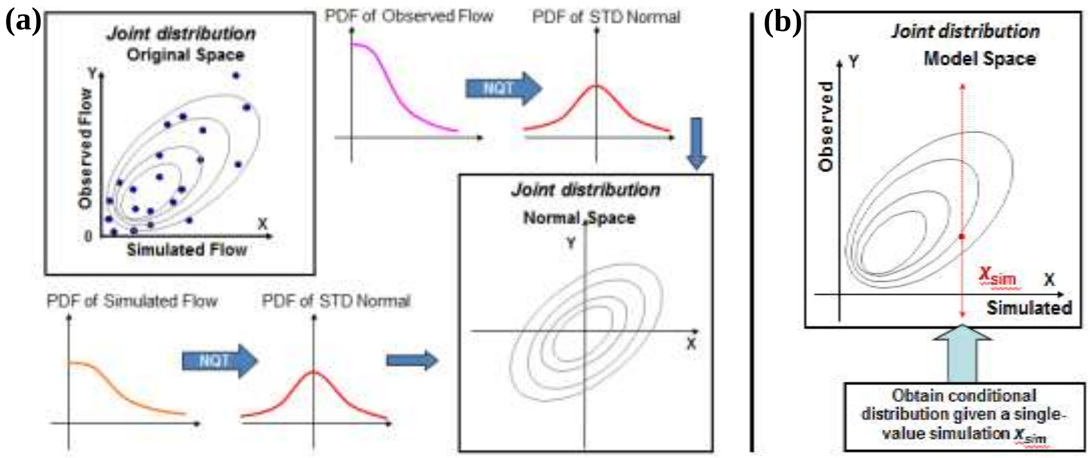


Figure 3: Illustrations of a) normal quantile transform (NQT) and b) conditional probability distribution

EnsPost transforms both the observed and simulated flows via NQT (Figure 3a), and then estimates the conditional probability distribution of the (to-be-realized) observed flow given the simulated flow (Figure 3b) and the most recently observed flow via linear regression in the normal space. The particular regression (or time series) model used in EnsPost is called the first-order autoregressive model with an exogenous input, or ARX(1,1) (Box and Jenkins, 1976), shown in Eq.(1) below. The predictors of the model are the model-simulated flow and the most recently observed streamflow. The predictand of the model is the (to-be-realized) observed flow valid at the same time as the model-simulated flow. Additional details may be found in Seo et al. (2006).

$$Z_{o,k+1} = (1 - b)Z_{o,k} + bZ_{s,k+1} + \mathrm{E}_{k+1} \quad (1)$$

where $Z_{o,k}$ and $Z_{o,k+1}$ denote the normalized observed flows at time steps k and k+1, respectively, $Z_{s,k+1}$ denotes the normalized model-predicted flow at time step k+1, E_{k+1} denotes the random error representing the hydrologic uncertainty at time step k+1 in the normal space, and b denotes the weight given to the normalized model prediction ($0 \le b \le 1$).

The regression model, ARX(1,1), is calibrated using the historical time series of observed flow and the corresponding model simulated flow. The statistical properties of observed flow and the error in the model simulation vary according to season and the magnitude of flow. As such, the NQT curves and the regression parameters are stratified according to season and magnitude of simulated flow. In EnsPost, the user may define different levels of seasonal stratification (biannual, 4-seasonal or monthly) and choose a threshold flow to stratify the regression parameters according to the magnitude of the simulated flow. The level of seasonal stratification and the threshold flow are selected such that, in each category, nonstationarity and heteroscedasticity are reduced as much as possible so that the magnitude of variability in streamflow does not vary too much in time (i.e. reasonably stationary) or depend too much on the magnitude of streamflow (i.e. reasonably homoscedastic), and different categories capture disparate temporal correlation structures (e.g., very fast/slowly-decaying serial correlation in high/low flows). In practice, however, the period of available recorded data may not be large enough to allow monthly, or even 4-seasonal, stratification.

The parameters of the regression model are optimized by minimizing the Mean Continuous Ranked Probability Score (CRPS, Hersbach, 2000) of the post-processed streamflow ensembles. The CRPS is one of the most widely used performance measures in ensemble verification and reflects multiple attributes, including reliability and resolution. Ideally, one would like to see the error in the model simulation to be completely random (i.e. white-noise). In reality, however, the above error is very often correlated in time. Such non-white error structures arise because ARX(1,1) is a very simple model and can only capture the first-order autoregressive (i.e. Markovian) behaviors of the error. In EnsPost, this temporal dependence of the error is modeled as first-order autoregressive (AR(1)), the details of which may be found in Regonda et al. (2012). Figure 4 shows examples of streamflow ensembles from EnsPost for the Snake River near Montezuma (SKEC2) in the CBRFC's service area. Note that ARX(1,1) and AR(1) do a reasonably good job of reproducing the noisiness and temporal pattern of variability present in the observed flow.

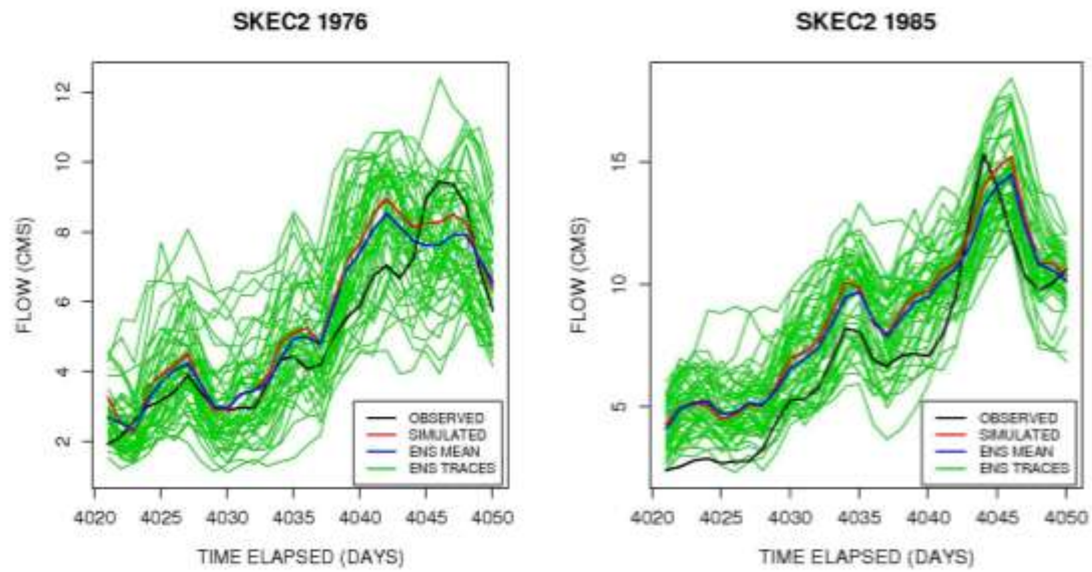


Figure 4: Example streamflow ensembles from EnsPost. The plot consists of observed flows (black), simulated streamflows, ensemble traces (green), and ensemble mean (blue); the ensemble mean is simply the arithmetic average of the ensemble traces of streamflow

2.3 Assumption and Limitations

EnsPost is a purely statistical technique that combines probability matching and linear regression (albeit in normal space). It assumes that the statistical relationships estimated from the historical data stay the same. If the climatological distribution of the observed flow changes due, e.g., to climate change or urbanization, the above assumption no longer holds. The regression model used in EnsPost is very parsimonious (it has only a few parameters) and hence does not require a large amount of data. Probability matching, on the other hand, requires reliable estimation of the empirical cumulative probability distribution functions (CDF) particularly in the all-important upper tail of the distribution and is very data-intensive. Experience so far has shown that at least 20 years' worth of data is necessary to obtain reasonably reliable parameters with 2-season (wet and dry) stratification.

When the above assumptions and general requirements are met, EnsPost performs as designed. Figure 5 shows examples of the model-simulated flow vs. the verifying observed flow for Lake Mendocino (LAMC0, 1962-2002) and Hopeland (HOPC1, 1961-2004) in the CNRFC's service area. Also shown in the right-hand side of the figure are those of the cross-validated ensemble mean flow from EnsPost vs. the verifying observed flow. The ensemble mean is simply the arithmetic average of the ensemble traces of streamflow obtained from EnsPost by post-processing the model-simulated flow. Note that EnsPost successfully corrects the very small bias in the LAMC0 simulation (but little or no improvement otherwise) and the rather large bias in the HOPC1 simulation, resulting in substantial improvement over the model simulation before post processing.

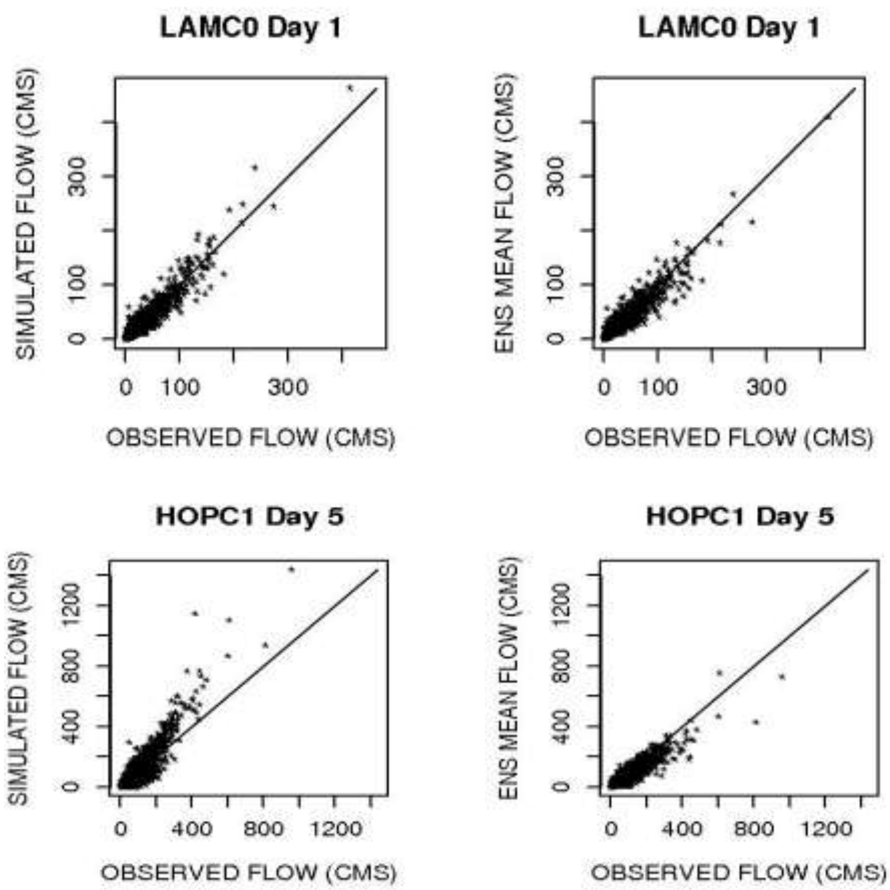


Figure 5: (left) Examples of model-simulated flow vs. verifying observation and (right) ensemble mean flow from EnsPost vs. verifying observed observation.

The statistical properties of the simulation error depend greatly on the streamflow generation mechanism. For example, simulation of rain-on-snow events tends to have larger errors. Modeling such storm type-dependent errors reliably, however, requires a much larger amount of training data, which is not likely to be available. As such, great care should be taken in applying EnsPost to model simulations with disparate errors. Figure 6a shows the model-simulated flow vs. the verifying observation for Saxton (SAXP1) in the Juniata River Basin in the MARFC's service area. Figure 6b shows the corresponding cross-validated ensemble mean flow from EnsPost vs. the verifying observation. The parameter estimation period coincided with the API calibration period of Sep 1963-Jan 1974. The annotated data points are associated with rain-on-snow events in 1979 and 1996. Note that EnsPost is not successful in reducing the errors in these outlying model simulations.

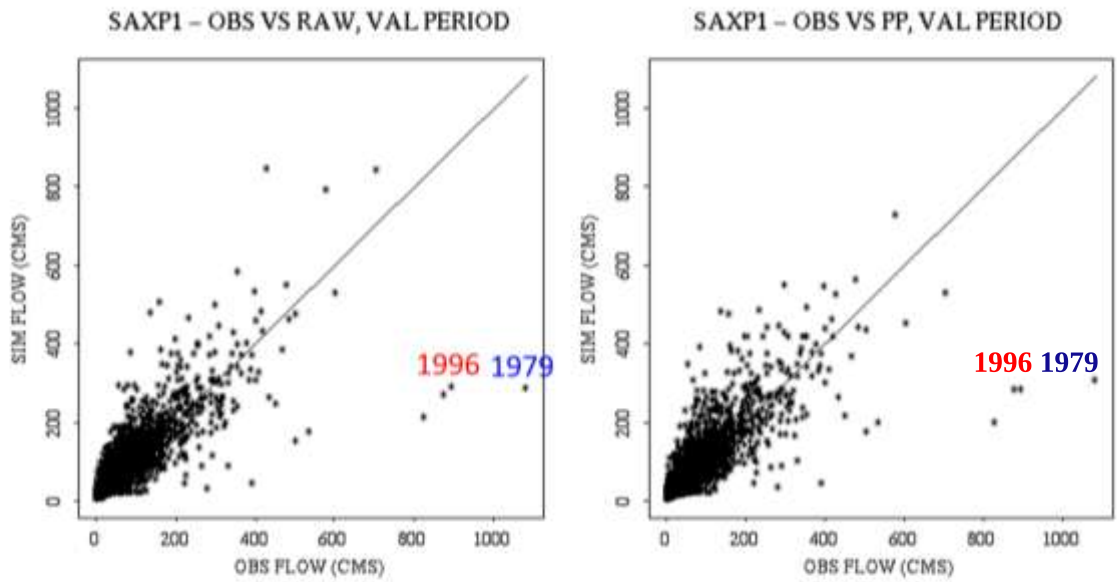


Figure 6: a) Model-simulated flow vs. verifying observed flow for Saxton, PA, and b) the corresponding ensemble mean flow from EnsPost vs. the verifying observed flow. The annotated data points are rain-on-snow events.

EnsPost does not explicitly consider timing, or phase, errors. As such, in the presence of significant timing errors, the post-processes ensemble traces may not be very realistic. Finally, EnsPost assumes that streamflow has a degree of predictability as expressed by serial correlation, and that the model simulation is skillful. For regulated flow, however, the above assumptions may not hold and hence EnsPost may be of very limited utility. Figure 7a shows the model-simulated flow vs. the verifying observation for Raystown Dam on the Raystown Branch of the Juniata River in the MARFC's forecast area. Figure 7b shows the corresponding ensemble mean flow from EnsPost vs. the verifying observation. The ensemble mean results are from parameter estimation and hence offer an assessment of the goodness of the statistical model used in EnsPost for dealing with regulated flows. Note that, while EnsPost reduces the very large errors associated with regulated flows, it does so only at the expense of introducing a large bias to the overall results. Figure 8 shows examples of the ensemble traces generated by EnsPost when the observed flow is subject to regulation. Note in the figure that EnsPost is largely unable to capture the unnatural temporal patterns in the observed flow associated with regulations.

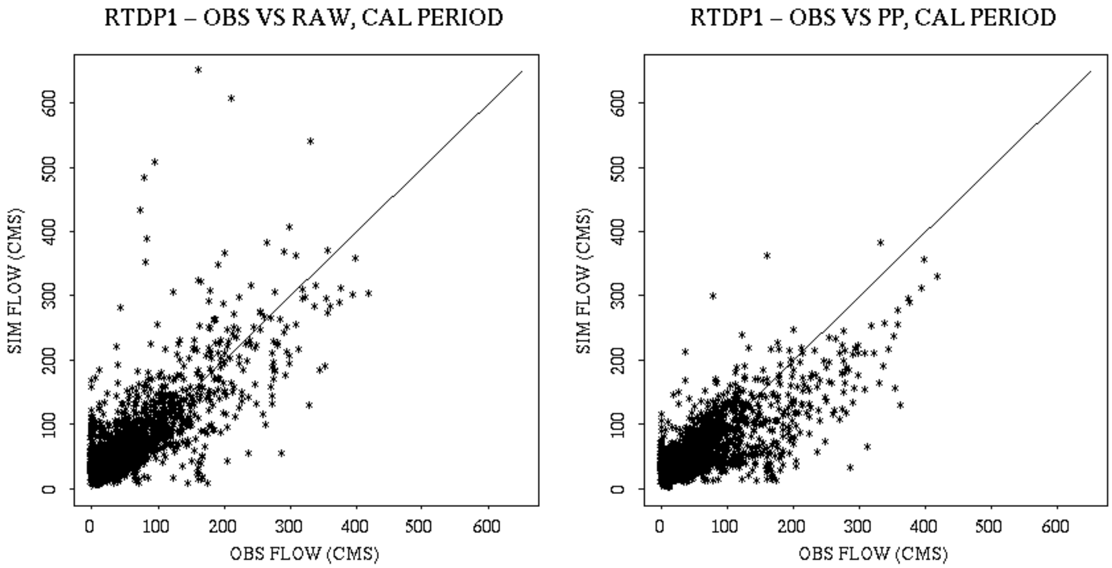


Figure 7: a) Model-simulated flow vs. verifying observed flow for Raystown Dam, PA, and b) the corresponding ensemble mean flow from EnsPost vs. the verifying observed flow.

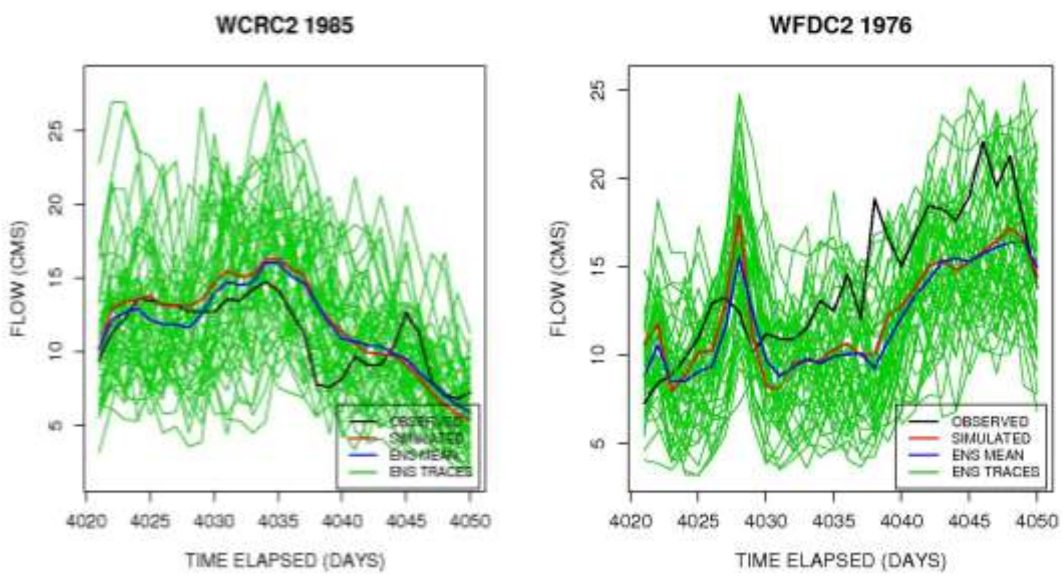


Figure 8: Example streamflow ensembles from EnsPost for regulated flows: a) Willow Creek Reservoir Near Granby, CO, and b) Williams Fork Reservoir near Parshall, CO.

Currently, the EnsPost operates at daily time scale due to the availability of long periods of streamflow record at that scale. As such, EnsPost requires aggregation of sub-daily flows (e.g., hourly, 6-hourly flow) to mean daily flow and disaggregation of mean daily flow to sub-daily flows. The disaggregation scheme currently used is very simple: mean daily flow is proportionally scaled to sub-daily flows (e.g., hourly, 6-hourly flows) based on the sub-daily model-simulated (model-forecast, if in real time) flows such that the post-processed mean daily flow is preserved.

2.3.1 Applying for a downstream location

For a downstream location, the model simulation that contains hydrologic uncertainty relative to the verifying streamflow observation at that location is the combined flow. As such, the sum of the routed flow from upstream and the local flow from downstream should be post-processed, rather than the local flow.

2.4 Error models

EnsPost has three different procedures for post processing. While they are described as different, they belong to the same family described in the Methodology Section:

1. Probability Matching
2. Error Model Stochastic
3. Error Model Deterministic

The above procedures named as PM (Probability Matching), ERS (Error Model Stochastic) and ERD (Error Model Deterministic) for the CHPS configuration. All three procedures above require a set of parameters be specified for the EnsPost calibration (i.e., running the *EnsPostPE*). We refer to these parameters as the *a priori* parameters, as listed below:

1. seasons table: Specify biannual (wet and dry), 4-seasonal (spring, summer, fall and winter) or monthly (Jan through Dec)
2. **OBS_OMEGA:** Sets the omega parameter controlling the upper tail of the empirical observed cumulative distribution function beyond the largest observed value.
3. **SIM_OMEGA:** Sets the omega parameter controlling the upper tail of the empirical simulated cumulative distribution function beyond the largest simulated value.
4. **CUTOFF:** Sets the probability associated with the streamflow cutoff value separating high flows from low flows.
5. **INT_MAX:** Sets the upper bound on the region used to compute the numerical integration that is used within the back-transformation.
6. **INT_MIN:** Sets the lower bound on the region used to compute the numerical integration that is used within the back-transformation.
7. **INT_NUM:** Sets the number of intervals used between the smallest and largest observed values in normal space in the computation of the numerical integration within the back-transformation.
8. **CALIB_DAYS:** Sets the lead time in days at which calibration should be performed, allowing the user to find the parameters resulting in the best performance at any lead time.
9. **TRACES**: Specify the number of ensemble traces to be produced as part of the EnsPost calibration

While some parameters, such as choice of seasons, are relatively intuitive, other parameters require detailed understanding of the technical details and calculation of verification metrics of the EnsPost PE ensembles generated for different options. We plan to provide guidance on values of these parameters for the next HEFS development release, until then it is recommended to use default options.

3 EnsPostPE Reference Manual

3.1 Overview

The parameters generated are tarred/gzipped and stored on the local file system, being accessed via run file property entries in the EnsPost module configuration files. The EnsPostPE guides the user through a step-by-step estimation process that includes setup, acquiring data files, estimating parameters with default or user-defined options, and accepting/zipping those parameters. It runs as a FEWS explorer plug-in, being seamlessly integrated within the CHPS/FEWS interface, and provides diagnostic capabilities.

This section of the manual describes how to use the EnsPostPE software interface to accomplish parameter estimation and provides details about all interface components. It is recommended that users read Section 3.2, Getting Started, prior to using the software, and refer to the other sections as needed while using the software. This manual is available via the EnsPostPE help functionality.

3.2 Getting Started

The EnsPostPE guides the users through a step-by-step procedure outlined in Section 3.2.3, providing tools to allow for quality-controlling data and analyzing the parameters. This section provides basic background material pertinent to the understanding of the EnsPostPE software in order to get started using the software. It explains:

1. Inputs to the EnsPostPE.
2. How to run the EnsPostPE.
3. The parameter estimation procedure through which the EnsPostPE guides the users and how that procedure connects to the interface components.
4. Core concepts for understanding and use of the EnsPostPE.

3.2.1 Inputs to the EnsPostPE

The purpose of EnsPost is to account for hydrologic uncertainty in the hydrologic forecasts for the RFC forecast points. To quantify the hydrologic uncertainty, the EnsPost needs to be trained using the data that reflects the hydrologic uncertainty only, i.e., simulated streamflow (or, equivalently, forecast streamflow with perfect future meteorological forcing). For the downstream points, the model simulation for the EnsPostPE is combined flow, i.e., the sum of routed flow from upstream and local flow from downstream. The combined flow simulation is used because the observed flow at a downstream point is combined flow from all upstream points.

3.2.1.1 Steps and checks before inputting the data into the EnsPost PE application:

1. Acquire historical simulated streamflows (SQIN or QINE) and corresponding observed streamflows (QME) and create separate piXML files for simulated and observed streamflows. It is important to produce historical simulated streamflows from the same configuration that is used for operations using the CHPS/FEWS.
2. Verify that the data in these files corresponds to the period of the record that is used for EnsPost calibration.

3. Verify that the validation time is mentioned correctly in both files of simulated and historical observed flows. It is critical that the time system in the piXML files is correct. Typically, the QME is stored in Data Card format (in local time) and converted to piXML. In converting the files, the data must be shifted correctly and/or the time system correctly identified in the piXML. For SQIN, this is handled in the CHPS configuration, but the “import” configurations related to the time system should be set properly.
4. Verify the following in the piXML files:
    - Location id – needs to be same in both observed and simulated data files.
    - Parameter id – for observations it should be QME, i.e., 24-hr average value and for simulations it should be either SQIN or QINE.
    - Time step unit – make sure that the values are in correspondence with the model run for the simulated flows and the measurement intervals for observed flows.
    - Flow units – check that the units are correct.
5. Develop annual hydrographs using the historical observed streamflows and identify number of seasons and months in each season
6. Upload piXML files of historical observed and simulated flow at /Models/hefs/hefsEnsPostPERunArea/piXMLFiles

3.2.2 Running EnsPostPE

To use EnsPostPE, you must install it in a CHPS stand-alone as described in the *HEFS Release Install Notes* and then start the CHPS session. After starting CHPS, the main toolbar will include an **EnsPostPE Button**:

Click on this button to run the EnsPostPE. Log messages will be displayed in the standard CHPS **Logs Panel.**

3.2.3 The Parameter Estimation Procedure

The EnsPost parameter estimation step procedure is provided below. With each step, the sections describing how to use components of the EnsPostPE to perform the steps are referred to.

1. *Setup*
   Acquire historical simulated streamflows and corresponding observed streamflows to use. For the downstream points, the model simulation for the EnsPostPE is combined flow, i.e., the sum of routed flow from upstream and local flow from downstream. The data can be acquired via the CHPS pi service and/or exported piXML files.

2. *Estimate parameters*
   Specify user-defined estimation options and estimate the parameters of the EnsPost. Examine the quality of the estimated parameters to determine their acceptability.

3. *Accept (zip) parameter files*
   Create tgz files of parameters to be exported during operational ensemble generation. The parameters/generated CDFs will be zipped individually.

3.2.4 Core Concepts

This section discusses several concepts that are core the operations of the EnsPostPE.

3.2.4.1 The EnsPostPE Run Area

The EnsPostPE runs using files stored on the file system within the CHPS region directory:

Models/hefs/hefsEnsPostPERunArea

Files stored under that directory include run-time information files, historical data files, observed data files, archived parameter files, and parameter files. The user should never modify anything within the EnsPostPE run area unless specifically instructed to do so.

3.2.4.2 Run-time Information

EnsPostPE run-time information includes any information necessary for the EnsPostPE to execute and that needs to be remembered whenever the EnsPostPE is closed so that the user can pick-up where they left off upon restarting EnsPostPE. That run-time information includes the following:

- EnsPost location information, including mapped location ids and coordinates
- EnsPostPE default parameter settings
- Defined parameter zip groups

All other information, including the step status, is determined at run-time based on the contents of the EnsPostPE run area.
The run-time information is stored in a file underneath the system files directory within the EnsPostPE run area:

.systemFiles/runTimeInformation.xml

Do not modify this file unless instructed to do so by an OHD developer while debugging an issue. The file is updated once per minute while EnsPostPE is running and whenever EnsPostPE is closed.

3.2.4.3 FEWS PI-service Connection

EnsPostPE can acquire the observed streamflow data via the FEWS PI-service, and, in order to use the FEWS PI-service, the connection port number must be defined. After the CHPS-interface has started, check the **Logs Panel** for lines similar to the following:

11-04-2010 11:16:01 INFO - Started FewsPiServiceImpl on localHost : 8101
11-04-2010 11:16:01 WARN - Failed to start: SocketListener0@0.0.0.0:8100

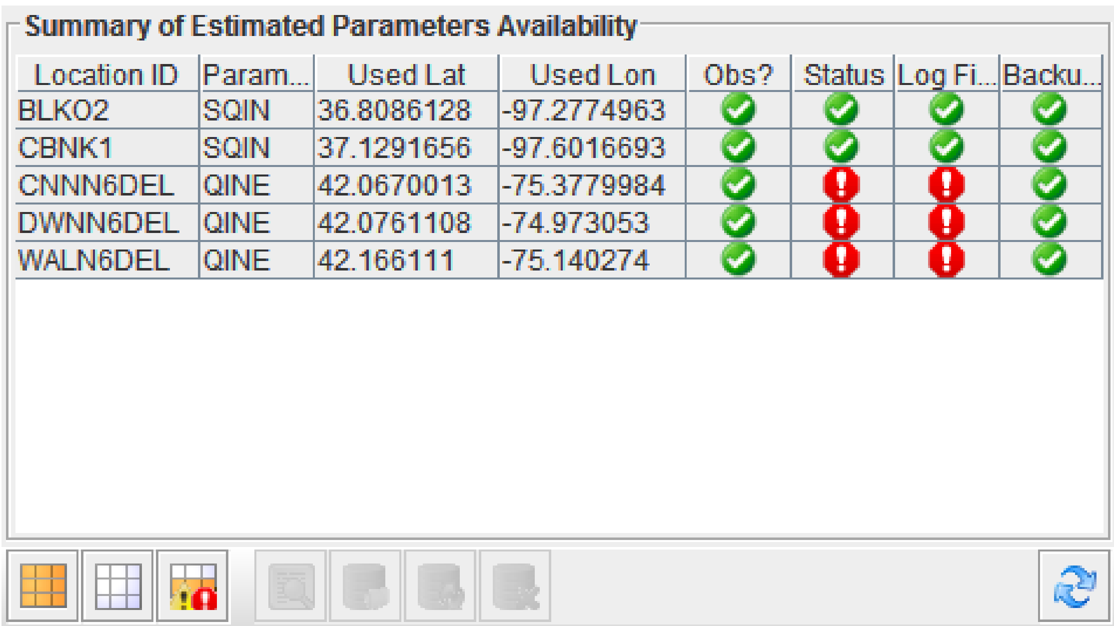
The line that begins with "Started FewsPiServiceImpl…" indicates that the port number (as highlighted above) of the FEWS PI-service session initialized for the currently running session of CHPS. This is the PI-service to which the EnsPostPE should connect. If the port number is not 8100 (the default) or is not the value which was setup during installation, then EnsPostPE must be directed to the correct port number. See Section 3.5.1.1 for details on how to change the port number in EnsPostPE.

3.2.5 General Graphical User Interface Components

Some graphical user interface (GUI) components are used many times within the EnsPostPE and are described below.

3.2.5.1 Generic Summary Table

Various panels within the EnsPostPE make use of a **Generic Summary Table**, which provides information about EnsPost locations and the status of steps performed. For example:



Location ID	Param...	Used Lat	Used Lon	Obs?	Status	Log Fi...	Backu...
BLKO2	SQIN	36.8086128	-97.2774963	✓	✓	✓	✓
CBNK1	SQIN	37.1291656	-97.6016693	✓	✓	✓	✓
CNNN6DEL	QINE	42.0670013	-75.3779984	✓	!	!	✓
DWNN6DEL	QINE	42.0761108	-74.973053	✓	!	!	✓
WALN6DEL	QINE	42.166111	-75.140274	✓	!	!	✓

Underneath the table is a tool bar which contains buttons that are panel specific; the example shown above is for the Estimation Subpanel (Section 3.4). Four buttons, however, are common to all **Generic Summary Tables:**

- **Select All Button**: Selects all rows of the table.
- **Unselect All Button**: Unselects all rows, clearing the table selection.
- **Select Rows That Need Processing Button**: Select all rows for which the status in the primary status column is not a check mark: or . These are the rows indicating locations for which the associated step needs to be performed or updated.
- **Refresh Button**: Refresh the table, determining the status of the rows from scratch. Clicking this button is usually not necessary, but may be required if the user changes files in the EnsPostPE run area.

When this table is used within a panel, it will be referred to as a **Generic Summary Table** associated with a specific step described in Section 3.2.3 and its panel specific buttons will be described.

3.2.5.2 Table Delete/Add and Status Columns

Many tables used within the EnsPostPE include a leading column that allows for deleting or adding rows, or status columns indicating the status of steps performed. Those columns display icons as follows:

Delete/Add Column:

- **Delete Icon**: Click to delete the row from the associated table. Sometimes this will cause a dialog popup confirming the delete.
- **Add Icon**: Click to add a row to the associated table.

Status Column:

- **Bad Status Icon**: Indicates that as step has not been performed or an error of some kind occurred while performing some other action.
- **Warning Status Icon**: Indicates that a step has been performed but needs to be updated (performed again).
- / **Good Status Icon**: Indicates that a step has been performed or some other action was successful. The icon is usually used to indicate success, but sometimes a .

For all status icons, a tool tip will display further information, such as the cause of failures or why a step needs to be updated. To see the message, leave the mouse cursor over the icon without moving it for a few seconds.

If a table within the EnsPostPE uses either a delete/add or status column, it will be stated in the description of that table. All **Generic Summary Tables** use a status column.

3.2.6 Format of the EnsPostPE section

Sections 3.3 and 3.9 are provided as a reference for the components of the EnsPostPE interface. Each section provides the following information:

- A description of the component panel to which the section applies.
- Any special considerations required for the panel.
- A listing of the interface components, including buttons, tables, lists, etc.
- Instructions for how to perform basic tasks using the components.

3.3 EnsPostPE Main Panel

Shown in **Error! Reference source not found.**, the EnsPostPE Main Panel is displayed as a plug-in to CHPS after initialization is completed. It includes three components:

- **Estimation Steps Panel**: Guides the user through the steps outlined in Section 3.2. A tabbed panel is provided for each of the steps.
- **Location Summary Panel**: Summarizes the status of the steps for each of the EnsPost locations. Also provides for the ability to run all steps for selected locations.
- **Diagnostics Display Panel**: Displays diagnostics that assist the user in quality controlling the data, deciding on options to use for estimation, and quality controlling and accepting the estimated parameters

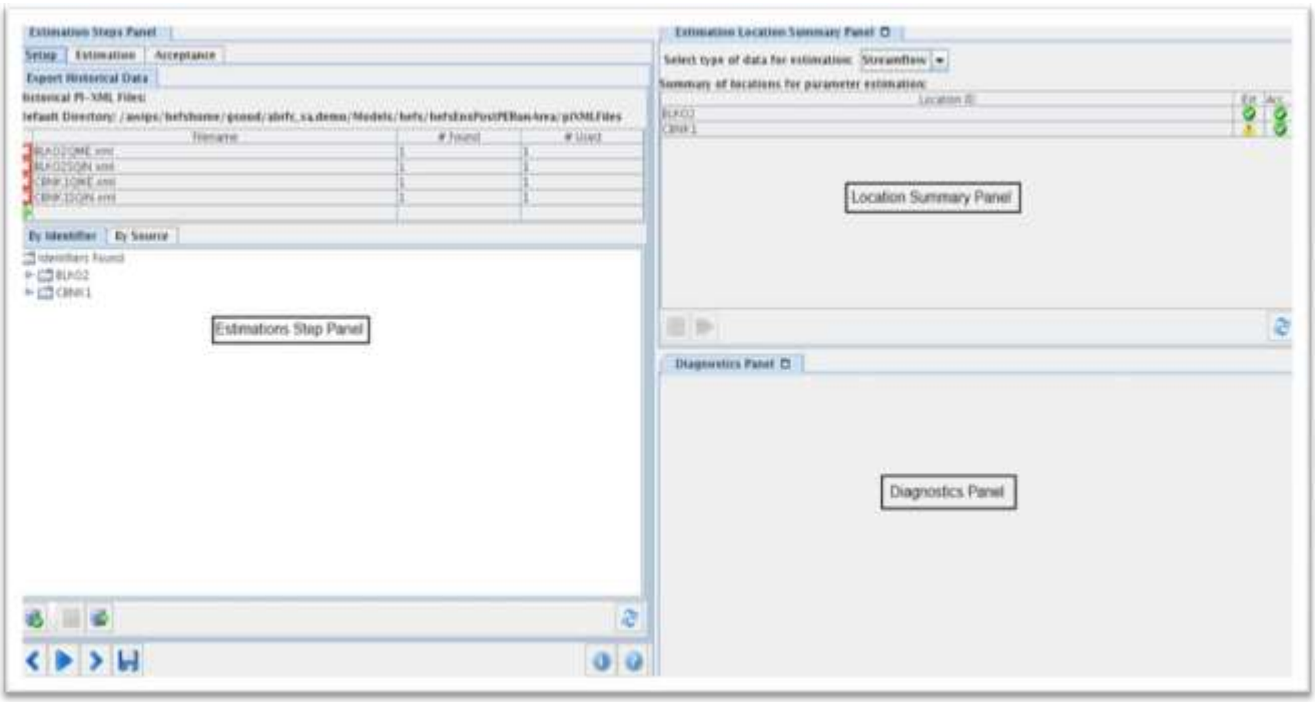


Figure 9: The EnsPostPE Main Panel, displayed upon start-up of the EnsPostPE

3.4 Estimations Steps Panel

The Estimation Steps Panel, shown in

Figure 10 is positioned on the left-hand side of the **EnsPostPE Main Panel** and displays tabbed subpanels that correspond to the steps of the EnsPost parameter estimation process. All of the tabbed subpanels are described in sections that follow. Also provided are buttons that facilitate navigating the tabbed subpanels, an information button, and a help button.

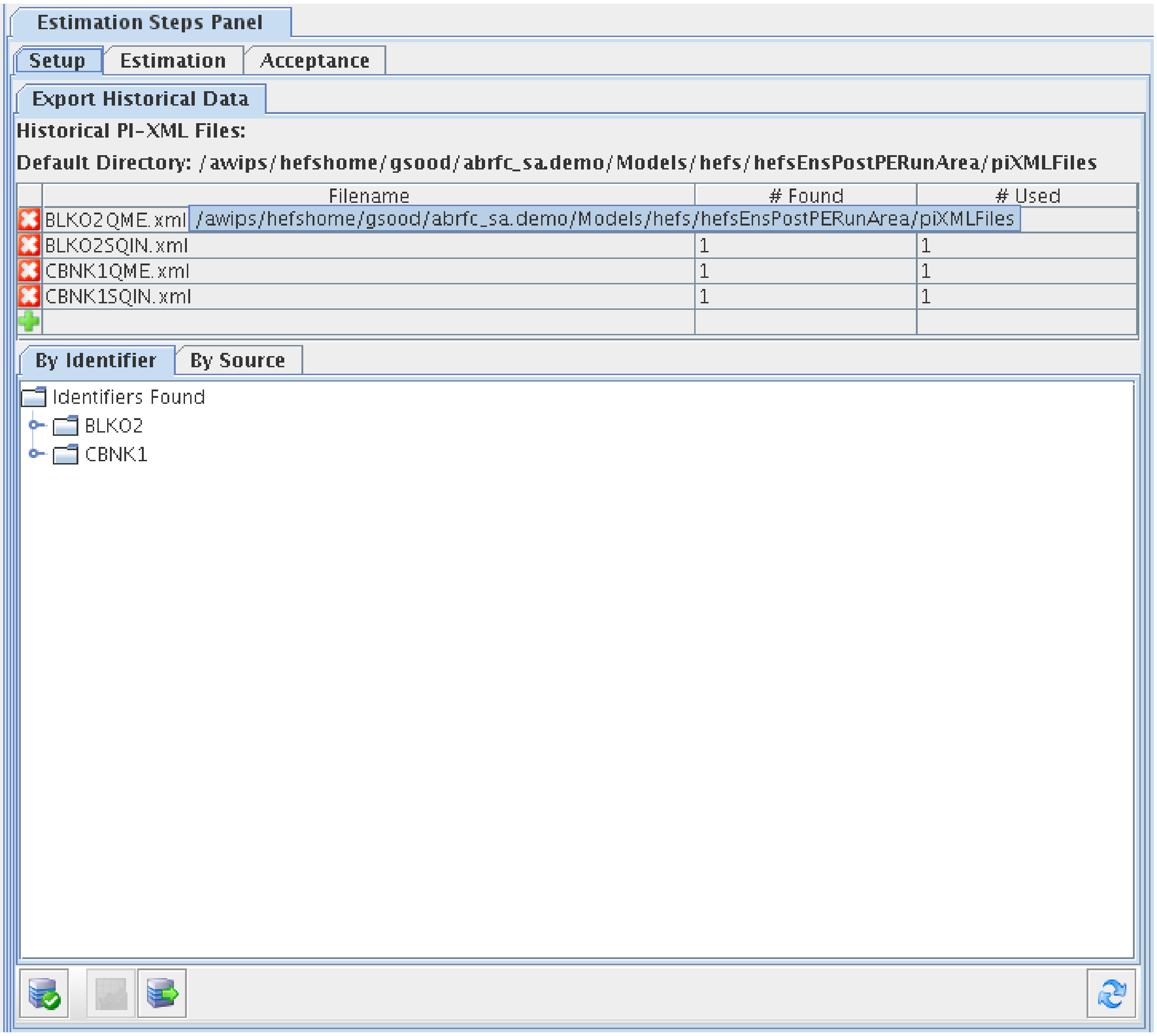
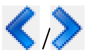


Figure 10: The Estimation Steps Panel

3.4.1 Components

The following describes the **Estimation Steps Panel** components:

- **Estimation Steps Tabbed Subpanels**: One tabbed subpanel is displayed for each of the estimation steps discussed in Section 3.2.3:

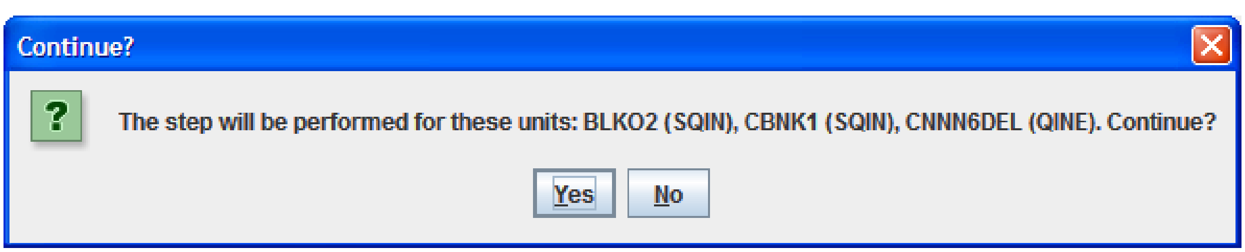
- To move between subpanels, either click on the tabs or on the **Back** and **Next** Buttons described below. A subpanel is said to be 'active' if its tab is selected and its contents are currently being viewed. For example, in the image above, the **Setup Subpanel** is active.
-  **Back/Next Buttons**: Click to navigate to the previous or the next step tabbed subpanel. The buttons are disabled if there is no previous or next subpanel.
-  **Perform Step Button** (**Run Button**): Click to run the step corresponding to the active tabbed subpanel. If there is no step to perform, as for the **Setup Tabbed Panel**, then this button will not be present. The button is enabled only if one or more EnsPost locations for which to perform the step are selected in the tabbed subpanel (see the description for the individual steps subpanels provided in following sections). A description of how to perform a step is presented below in Section 3.4.2.1. This button is not available in the **Setup Subpanel**.
-  **Save Run-Time Information Button**: Click to force an immediate save of the run-time information. EnsPostPE saves run-time information to a file that is loaded whenever it starts, enabling it to remember user settings. The file is saved once per minute while EnsPostPE is running, when EnsPostPE is closed, and when this button is clicked.
-  **About Button**: Click to display a dialog providing version information for the EnsPostPE.

   **Help Button**: Click to active help mode. When in help mode, the interface cannot be interacted with. Rather, the user can click on a component of the interface to receive help information tailored for the clicked component. The information is extracted directly from this manual and is displayed in the system's default internet browser. The component for which help will be provided is highlighted by a faded red box; for example:

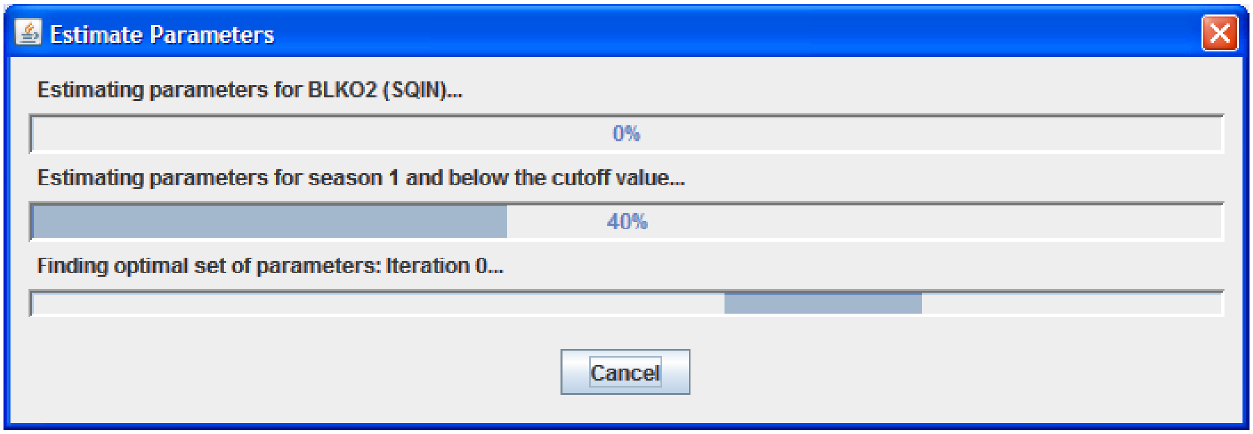
3.4.2 Usage

3.4.2.1 Performing a Parameter Estimation Step

A step is performed by making the corresponding step subpanel active, selecting EnsPost locations for which to perform the step, and clicking on the **Perform Step Button**. Upon clicking **Perform Step**, a **Continue Dialog** will be displayed allowing the user to confirm or cancel the run; for example:

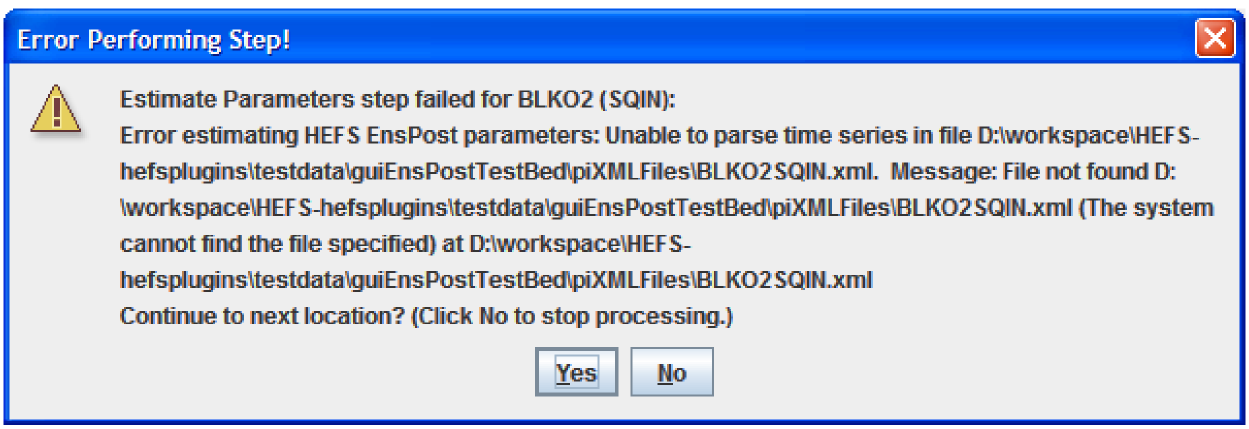


Click **Yes** to continue or **No** to cancel. If **Yes** is clicked, a **Step Progress Dialog** will be displayed providing the ability to cancel the step via a **Cancel Button**:



If the step fails for any reason, including if it was canceled, an error dialog will be displayed. If the step is only being performed for one EnsPost location or it is the last of multiple locations for which the step failed, then a **Step Failed Dialog** will be displayed explaining the cause of the failure:

Otherwise, an **Error Performing Step Dialog** will be displayed, giving the user the option to continue to the next selected EnsPost location (click **Yes** to continue, **No** to stop):



If the step is successful, the progress dialog will close with no additional dialog displayed.
If a step is canceled by clicking on the **Cancel Button** in the **Step Progress Dialog**, the EnsPostPE may not immediately cancel the step. Rather, it will wait until the step can be canceled cleanly without causing any problems. Upon clicking **Cancel**, the button will be disabled until the step can be canceled.

3.5 Setup Subpanel

The **Setup Subpanel** of the **Estimation Steps Panel**, shown in Figure 10, allows the user to setup the EnsPost locations for which parameters are to be estimated.

- Export required historical simulated streamflows and corresponding observed streamflows historical data: The EnsPostPE executes from its run area based on files therein. In order to compute parameters for a location, historical data must be present for that location within a FEWS pi-timeseries compliant XML or fastInfoset file in the EnsPostPE run area. Those files can be created from the hindcast workflow for each forecast basin or by acquiring time series via the FEWS PI-service and creating files from those time series. Exporting and verifying the available historical data is done during the setup phase.

Subpanels within the **Setup Subpanel** are defined and are described below. The usage section explains how to perform each of these steps using the interface components provided.

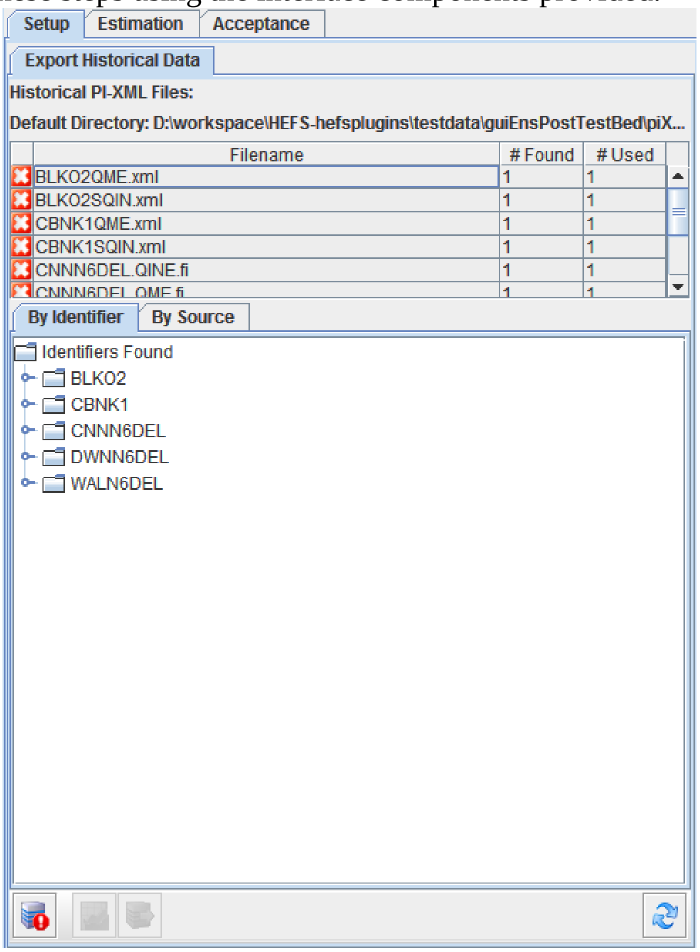


Figure 11: The **Setup Subpanel** of the **Estimation Steps Panel**.

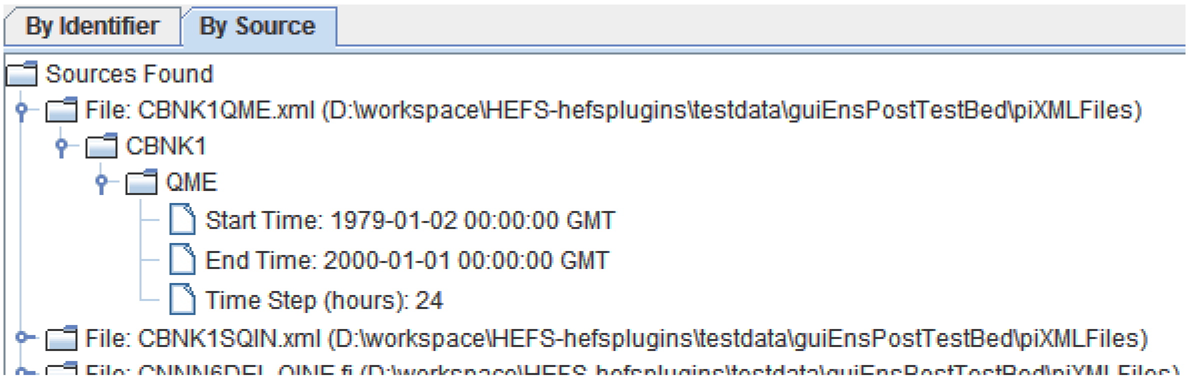
3.5.1 Export Historical Data Subpanel

The **Export Historical Data Subpanel**, shown in Figure 11, facilitates viewing and quality controlling of the data. The time series are gathered by examining files in the directory ‘piXMLFiles’ within the EnsPostPE run area (Section 3.2.4.1). Available data for the streamflow is displayed.

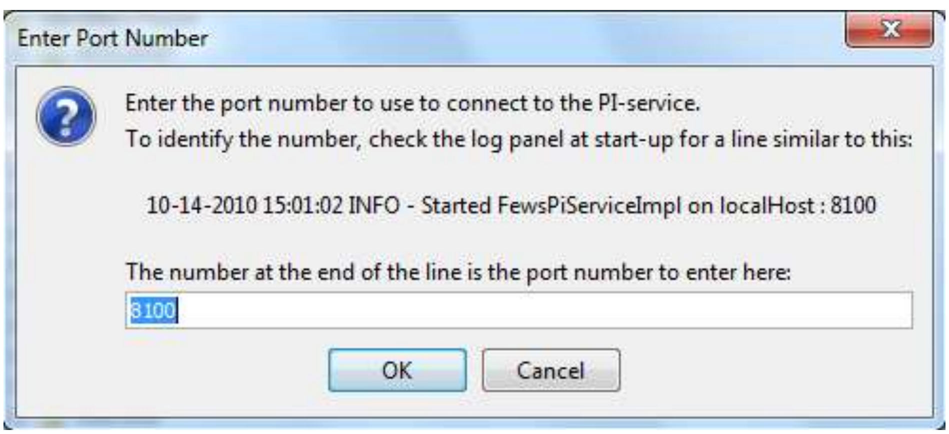
3.5.1.1 Components

- **Historical PI-XML Files Table**: Displays which files were found specifying historical time series. A delete column is included which, when clicked, removes the clicked row’s file from the file system. A confirmation dialog will be shown before the file is deleted.

- **By Identifier Tree/By Source Tree**: The contents of the files found are listed in two trees displayed via a tabbed panel: the **By Identifier Tree** displays the time series first by EnsPost location identifier (locationId and parameterId), while the **By Source Tree** displays the time series first by source file found. The information provided in the tree includes locationId, parameterId, source file, start time, end time, and time step of the time series found. Both trees are selectable. Expand the tree nodes in order to view this information. For example:



-  **Reconnect to CHPS PI-service Button**: Click to open an **Enter Port Number Dialog** that allows for entering a port number to use for connecting to the PI-service:



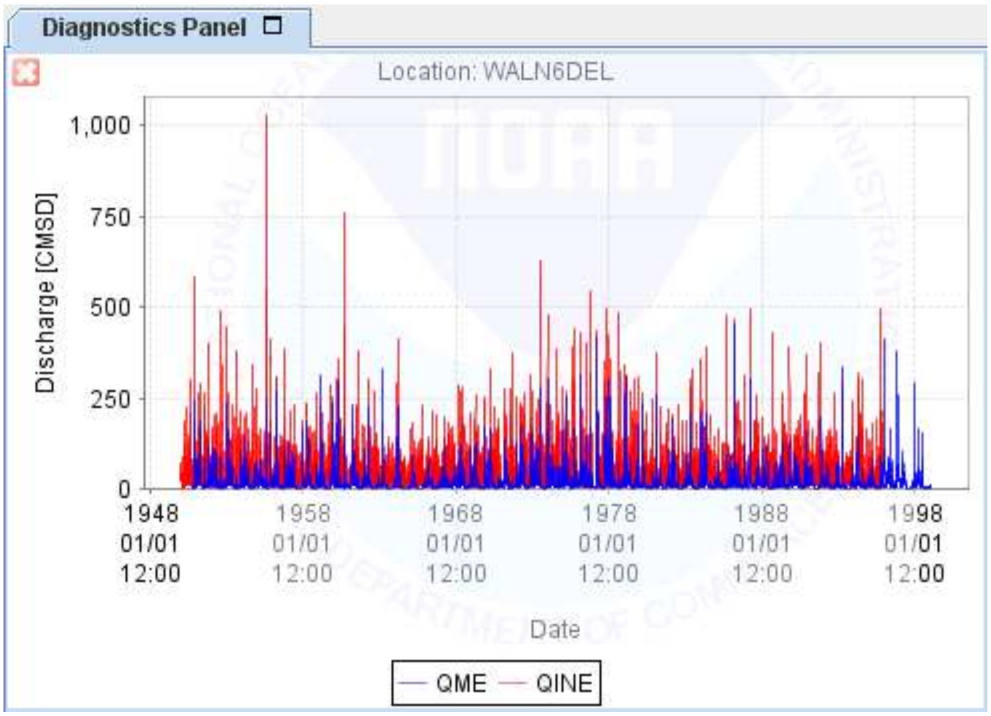
This is useful if the port number used previously (default is 8100) failed to yield a connection or connected to the wrong PI-service. A status icon is included within the larger icon,  indicates a good connections, while  indicates a bad connection. When the connection is bad, the **Export Time Series from CHPS DB Button** will be disabled. Detailed instructions for identifying this port number are provided in Section 3.2.4.3.

NOTE: It is possible for the button to indicate a good connection even though it connected to the wrong PI-service.

-  **View Button**: Click to view time series selected from either the **By Identifier Tree** or **By Source Tree**. To view a time series, all selected nodes or leaves in the tree must be for the same CHPS locationId and the same data type.
-  **Refresh Button**: Reread the files in the piXMLFiles directory of the EnsPostPE run area and reconstruct the trees. This needs to be clicked only if the files in the piXMLFiles are modified manually while running EnsPostPE, as in Section 3.2.1.1.

3.5.1.2 Diagnostics

The diagnostics displayed for this subpanel are the time series as provided in the XML or fastInfoset files. The time series are displayed as blue and red lines:



3.6 Estimation Subpanel

The **Estimation Subpanel** of the **Estimation Steps Panel**, shown in Figure 12, is used to perform Step 2 of the parameter estimation procedure in Section 3.2.3: estimate parameters. The panel includes two subpanels: the **Locations Summary Subpanel** and **Estimation Options Subpanel**. Each subpanel and components are described below.

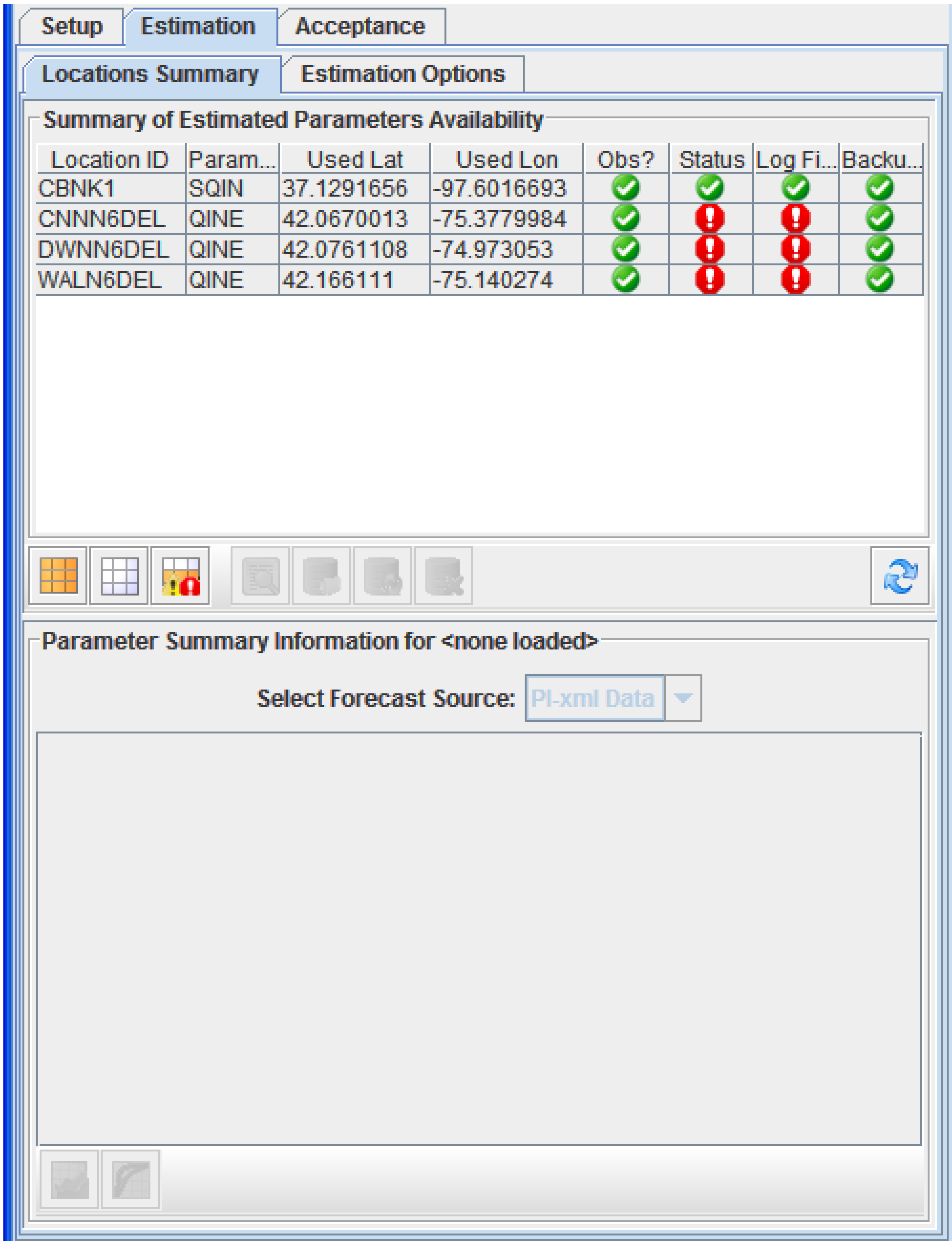


Figure 12 : The **Estimation Subpanel** of the **Estimation Steps Panel.**

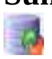
3.6.1 Locations Summary Subpanel

The **Locations Summary Subpanel**, shown in Figure 12, summarizes the status of estimation for all locations and allows the user view log files, delete parameters, backup parameters, restore parameters, and select diagnostics to display.

3.6.1.1 Parameter File Backups

The EnsPostPE allows for *one* set of backup parameters per location. Whenever estimation is performed for selected EnsPost locations, if parameters have already been estimated for those locations, they will be backed-up, while any parameters that were backed-up will be discarded. Those newly backed-up parameters can later be restored if the new active parameters just estimated prove to be less desirable.

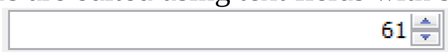
3.6.1.2 Components

- **Summary of Estimated Parameters Availability Table**: Allows the user to select EnsPost locations for which to perform the step and view for which locations the step has been performed. It is a **Generic Summary Table** (Section 3.2.5.1) and includes all the standard buttons. Furthermore, it includes two additional columns: the ‘Log File?’ column indicates if a log file is present for the current estimated parameters; the ‘Backup?’ column indicates if backup parameters exist for the selected location.
-  **View Log File Button**: Allows the user to view the contents of the log file for the estimated parameters. It opens up an **Estimation Log File Dialog** displaying the contents.
-  **Load Parameters Button**: Click to load parameters for one selected location from the **Summary of Estimated Parameters Availability Table**. Upon loading, the **Parameters Summary Information Table** (below) will be updated to reflect the loaded parameters.
-  **Restore Parameters Button**: Click to restore backup parameters for selected EnsPost locations. For the selected locations, the active and backed-up parameters will be swapped, making the backup parameters active and vice-versa. A **Continue? Dialog** will be opened allowing the user to confirm the restore.
-  **Remove Parameters Button**: Click to remove the active parameters. A **Backup Parameters? Dialog** will open asking if the user wants to make the parameters backup parameters. If **Yes** is clicked, the parameters are backed-up. If **No** is clicked, the parameters are discarded. If **Cancel** is clicked, the remove is not performed.
- **Select Forecast Source Choice Box**: Allows the user to select the forecast source for which to view parameter summary information within the **Parameter Summary Information Table** (below).
- **Parameter Summary Information Table**: Displays the parameters loaded from the parameter files. The table allows for multiple selections. The following columns are provided:
    - ‘Parameter Type’: A descriptive name of the parameter.
    - ‘# Months’: The number of months for which parameters were found.
    - ‘Minimum’: The smallest overall value found for the corresponding parameter.
    - ‘Maximum’: The largest overall value found for the corresponding parameter.
-  **View Button**: Click to view the parameters for selected rows from the **Parameter Summary Information Table**.

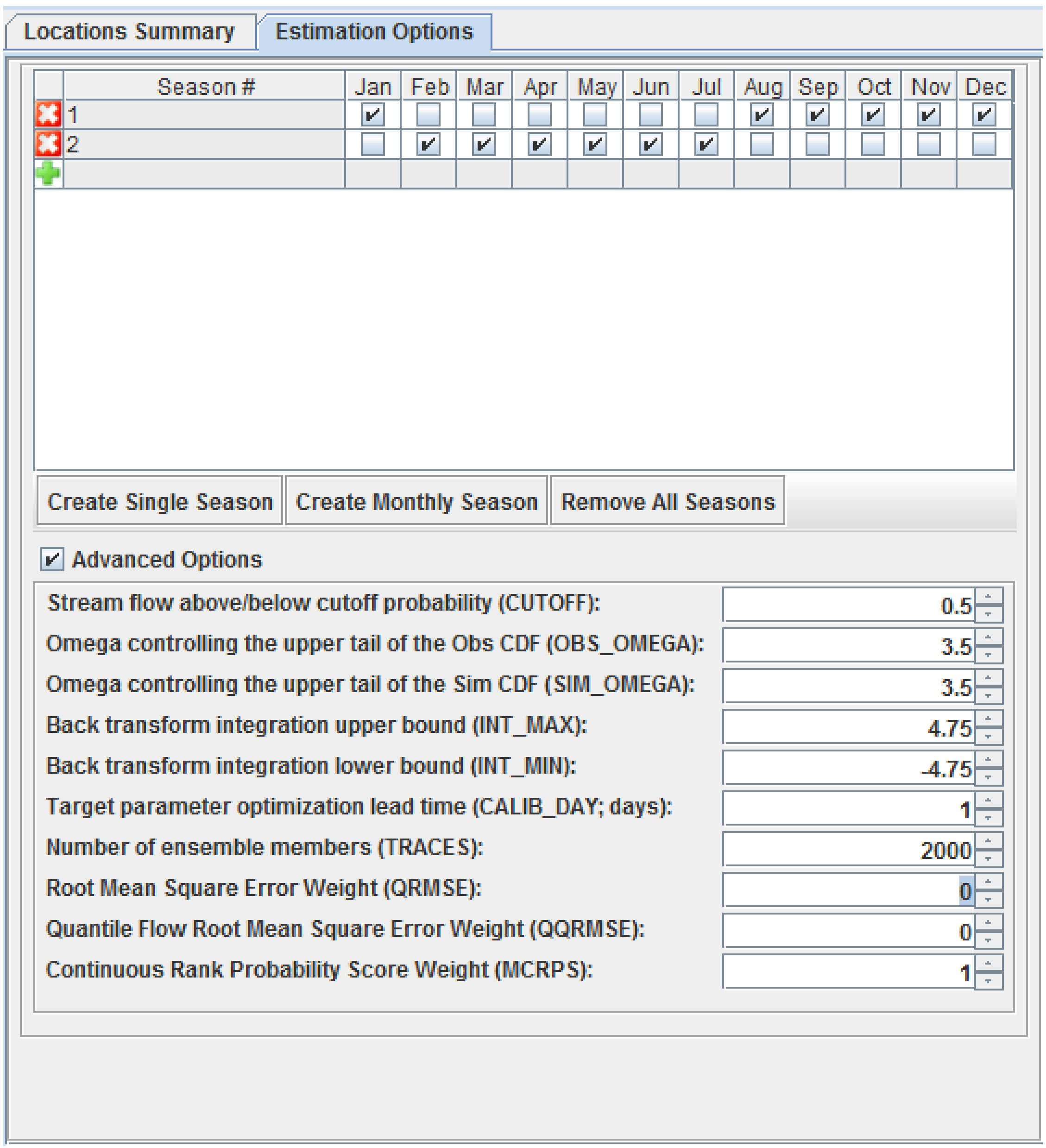
-  **View CDF Button**: Click to view the CDFs by month for the EnsPost location.

3.6.2 Estimation Options Subpanel

The **Estimation Options Subpanel** allows for users to specify options for the parameter estimation algorithm. All numerical parameters are edited using text fields with spinners; for example:



The number can be edited by clicking and typing or by clicking on the up or down arrows.



3.6.2.1 Seasons Table

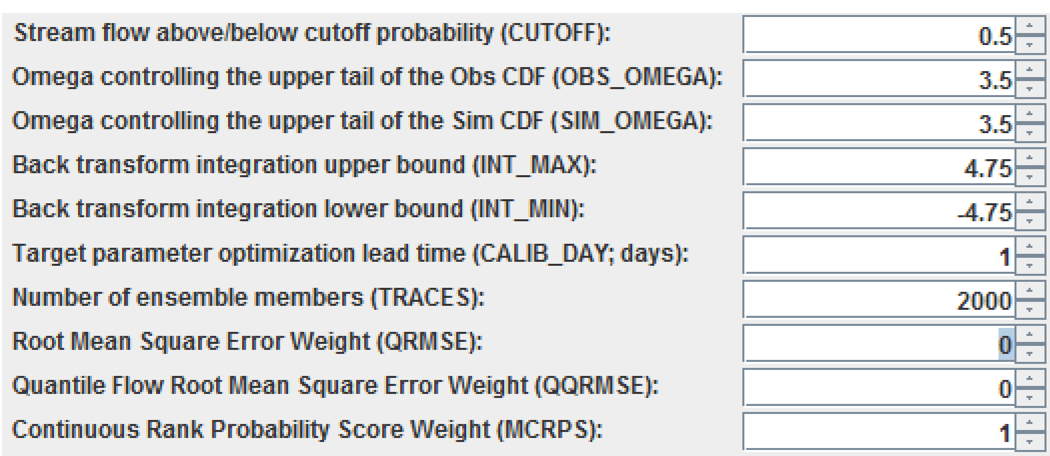
The seasons table allows the user to specify multiple seasons for the estimation. In order for the EnsPostPE to run, at least 1 season has to be created with at least 1 month checked. The table buttons are described in Section 3.2.5.2. There are some additional buttons:

- Create Single Season Creates a single season with every month checked
- Create Monthly Season Creates 12 seasons (1 for each month)
- Remove All Seasons Removes all seasons from the table.

3.6.2.2 Advanced Options Subpanel

The EnsPostPE has several advanced options that are user defined. Most of these will be modified only once.

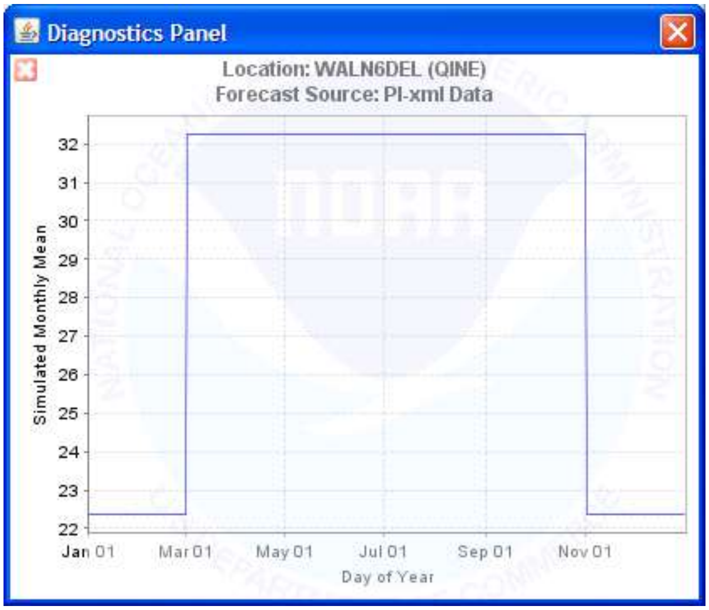
- **CUTOFF:** Sets the probability associated with the streamflow cutoff value separating high flows from low flows. *(Default value: 0.5)*
- **OBS_OMEGA:** Sets the omega parameter controlling the upper tail of the empirical observed cumulative distribution function beyond the largest observed value. *(Default value: 3.5)*
- **SIM_OMEGA:** Sets the omega parameter controlling the upper tail of the empirical simulated cumulative distribution function beyond the largest simulated value. *(Default value: 3.5)*
- **INT_MAX:** Sets the upper bound on the region used to compute the numerical integration that is used within the back-transformation. *(Default value: 4.75)*
- **INT_MIN:** Sets the lower bound on the region used to compute the numerical integration that is used within the back-transformation. *(Default value: -4.75)*
- **CALIB_DAYS:** Sets the lead time in days at which calibration should be performed, allowing the user to find the parameters resulting in the best performance at any lead time. *(Default value: 1)*
- **TRACES:** Sets the number of ensemble members. *(Default value: 2000)*
- **QRMSE:** Sets the Root Mean Square Error Weight. (*Default value: 0)*
- **QQRMSE: Sets the** Quantile Root Mean Square Error Weight. (*Default value: 0)*
- **MCRPS:** Sets the Continuous Rank Probability Score Weight. (*Default value: 1)*

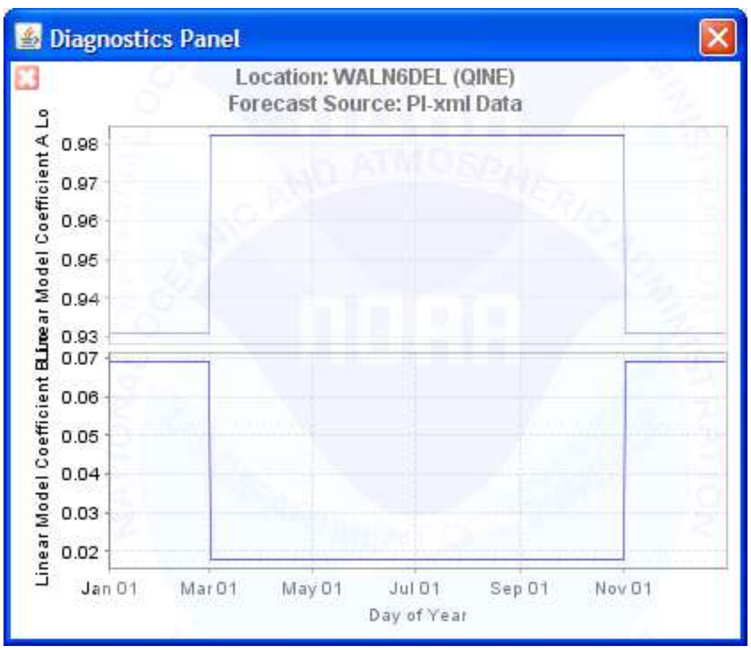


3.6.3 Diagnostics

The current diagnostic display provided when the **View Button** is clicked for the estimated parameters are designed primarily for data viewing and quality control. The diagnostic displays parameters selected within the **Parameter Summary Information Table**. The parameter values are displayed against the month of the year (1 – 12).

Provided below are two examples of diagnostic displays. The first is for a single parameter (QINE Estimated Monthly Mean) while the second is for multiple parameters (the QINE Linear Model Coefficient A Lo and B Lo):





3.6.4 Usage

3.6.4.1 Estimating Parameters

To estimate parameters, select one or more EnsPost locations from the **Summary of Estimated Parameters Availability Table** and click on the **Perform Step Button**. See Section 3.4.2.1 for details on how to perform a step using the **Perform Step Button** of the **Estimation Steps Panel**.

3.6.4.2 Loading Parameters and Viewing Diagnostics

To load parameters and view the diagnostics, do the following:

1. Select one EnsPost location (row) from the **Summary of Estimated Parameters Availability Table** of the **Locations Summary Subpanel**.
2. Click on the **Load Parameters Button**. A progress dialog will be displayed indicating that parameters are being loaded. This may take a minute or two. After completion, the **Parameter Summary Information Table** will update displaying the parameters loaded.
3. Select the forecast source for which you want to view parameters from the **Select Forecast Source Choice Box**. If the table is empty, then no parameters were loaded.
4. Select the estimated parameters (rows) that you wish to view from the **Parameter Summary Information Table**.
5. Click on the **View Button**.

3.6.4.3 Backing-Up Parameters and Restoring Backup Parameters

To backup parameters, select one or more EnsPost locations from the **Summary of Estimated Parameters Availability Table** and click on the **Remove Parameters Button**. When the **Backup Parameters? Dialog** opens, click on **Yes**. Upon completion, the 'Status' column of the **Summary of Estimated Parameters Availability Table** will display a indicating that no active parameters are available, while the 'Backup?' column will display a indicating that backup parameters are available. To restore backup parameters, select one or more EnsPost locations from the **Summary of Estimated Parameters Availability Table** and click on the **Restore Parameters Button**. When the **Continue? Dialog** opens, click on **Yes**. Upon completion, the 'Status' column of the **Summary of Estimated Parameters Availability Table** will display a or indicating that parameters are available, while the 'Backup?' column will display either a if there were active parameters when the button was clicked or if there were no active parameters.

3.7 Acceptance Subpanel

The **Acceptance Subpanel** of the **Estimation Steps Panel**, shown in Figure 13, is used to perform Step 3 of the parameter estimation procedure in Section 3.2.3: accept (zip) parameter files.

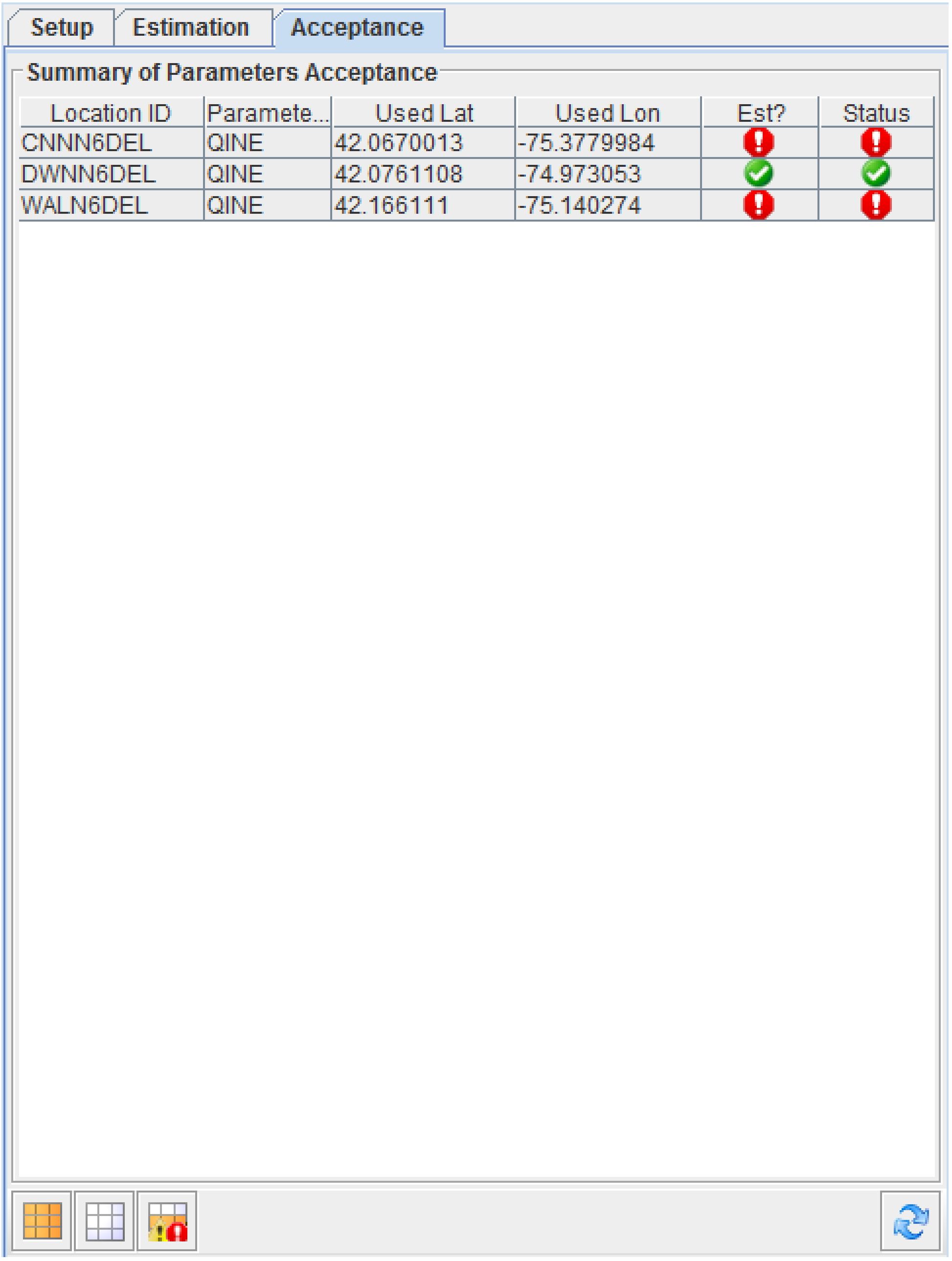


Figure 13 : The **Acceptance Subpanel** of the **Estimation Steps Panel**

3.7.1 About Parameter Tgz Files

As defined in Section 3.2.3, parameter tgz files that are created will be placed in the directory defined by ENS_POST_ROOT_DIR/ensPostParameters and its file name will match the following pattern:
<LocationID>.<ParameterID>.enspost.parameters.tgz

3.7.2 Usage

To zip up parameters for a particular location:

1. Select the row with the location ID in the Summary of Parameters Acceptance table
2. Click on the **Perform Step Button** 

see Section 3.4.2.1 for details on how to perform a step using the **Perform Step Button** of the **Estimation Steps Panel**.

3.8 Location Summary Panel

The **Location Summary Panel**, shown in Figure 14, summarizes the status of all steps to perform described in Section 3.2.3 for all EnsPost locations. The panel also includes a **Select Type of Data for Estimation Choice Box** for selecting the active estimation data type, a **Goto Step Panel Button** to facilitate quickly navigating the **Estimation Steps Panel**, and a **Run All Steps Button** to allow for performing all steps for multiple selected locations.

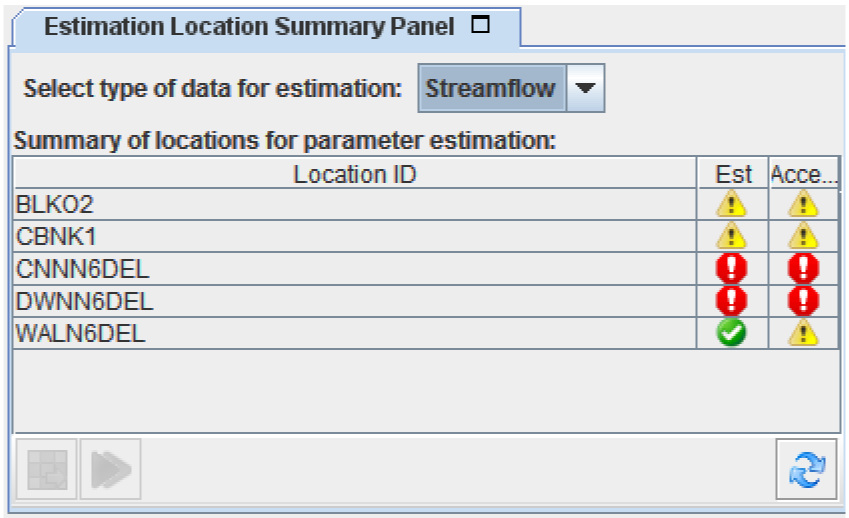


Figure 14 : The **Location Summary Panel**

3.8.1 Components

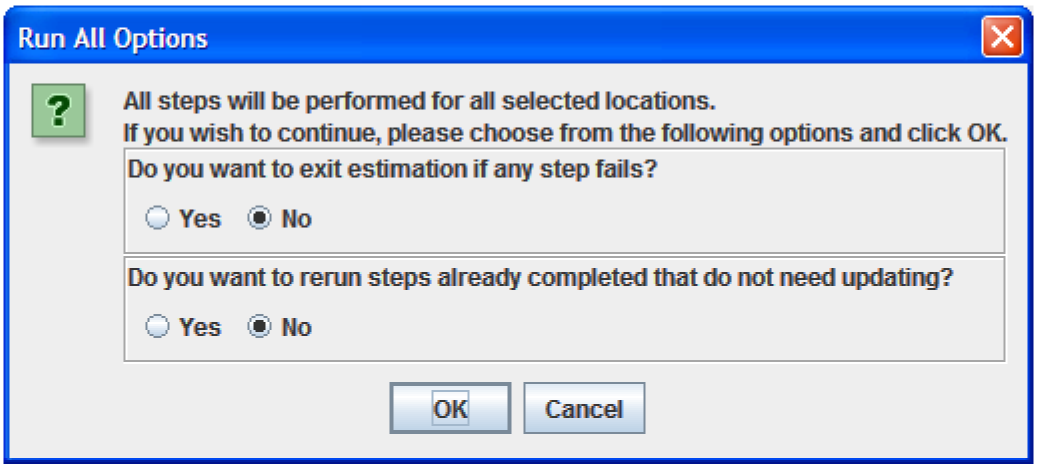
- **Select Type of Data for Estimation Choice Box**: Allows for selecting the active estimate data type ("Streamflow").
- **Summary of Locations for Parameter Estimation Table**: Summarizes the status of all steps to perform (except the setup step) for all EnsPost locations for the active estimation data type. The columns are as follows:
  - 'Location ID': The location id of the EnsPost location.
  - 'Est': Displays the status of Step 2: estimate parameters.
  - 'Accept': Displays the status of Step 3: accept (zip) parameter files.
- **Goto Step Panel Button**: Click to make the step subpanel corresponding to the selected column of the **Summary of Locations for Parameter Estimation Table** active within the **Estimation Steps Panel**. Also, if appropriate, it selects rows of the **Generic Summary Table** for that subpanel for the EnsPost locations selected within the **Summary of Locations for Parameter Estimation Table**. After clicking this button, the user should be able to click on the **Perform Step Button** to perform the step for all selected locations.
- **Run All Steps Button**: Click to run all of the steps for the selected EnsPost locations. Upon clicking a **Run All Options Dialog** will be displayed. Click on **OK** to continue with the run or **Cancel** to cancel it.
- **Refresh Button**: Click to refresh the status columns of the **Summary of Locations for Parameter Estimation Table**. This will also trigger a refresh of status columns in all subpanels of the **Estimation Steps Panel**.

3.8.2 Usage

3.8.2.1 Running All Steps For Multiple EnsPost Locations

To perform all steps for desired EnsPost locations, do the following:

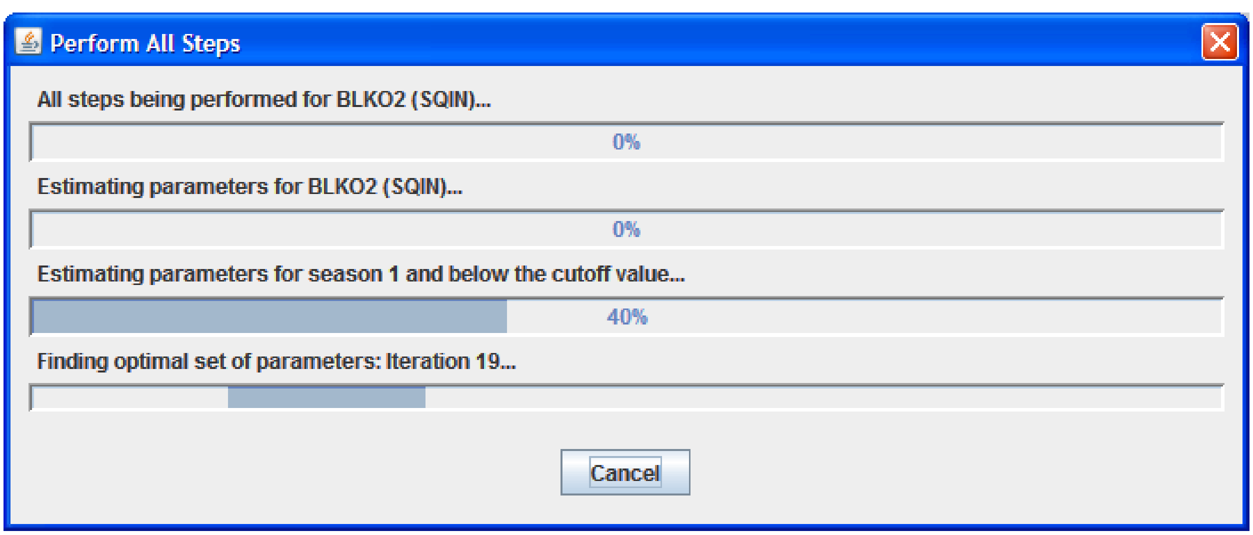
1. Select the rows for the desired EnsPost locations from the **Summary of Locations for Parameter Estimation Table**.
2. Click on the **Run All Steps Button**. A **Run All Options Dialog** will open:



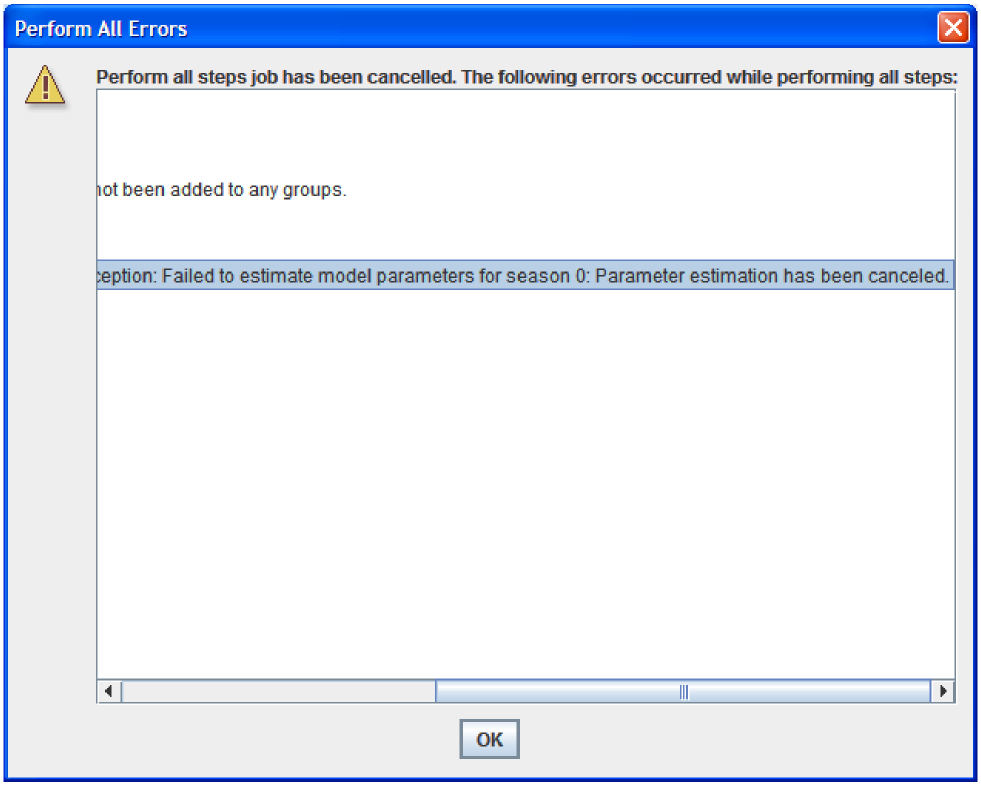
There are 2 options that the user can set:

- Specify if the Run All is to exit as soon as any step fails for any reason.
- Specify if the Run All should re-run already completed steps.

3. Set the options as desired and click **OK** (click **Cancel** to stop the run all). A progress dialog will open:



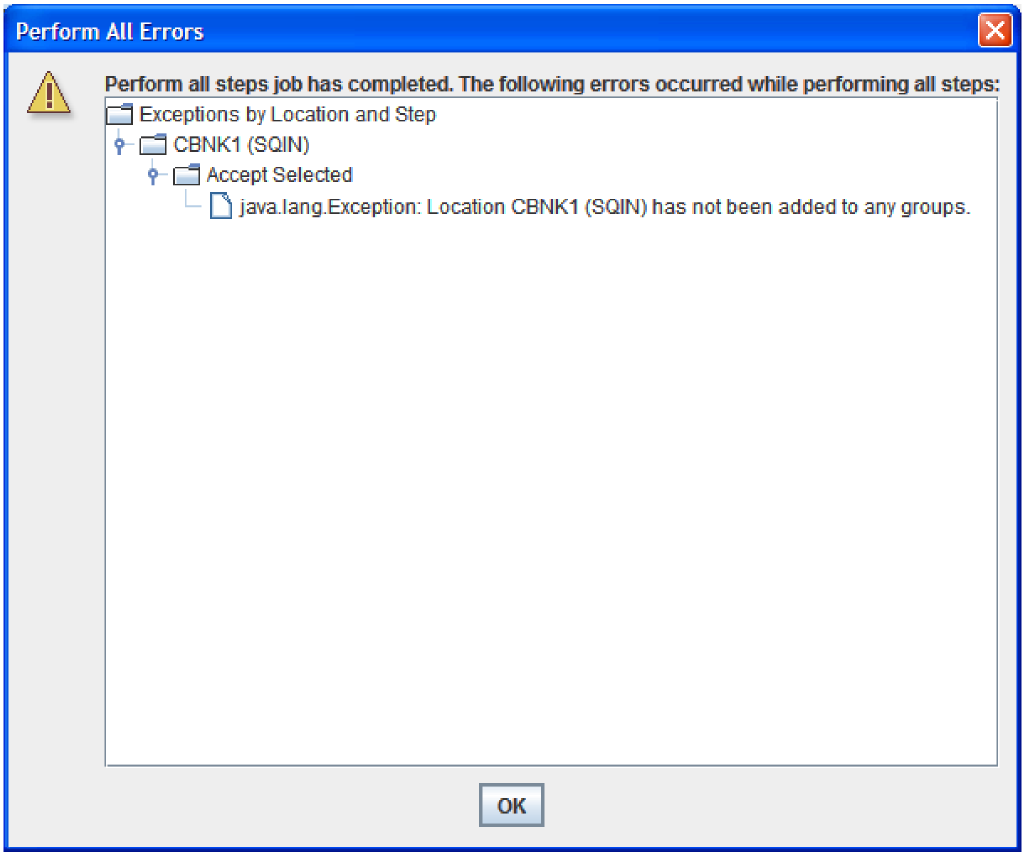
The run all can be canceled at any time by clicking on the **Cancel Button**. The run all will stop at the next opportunity and a **Perform All Errors Dialog** will be displayed where the last leaf will indicate that the user canceled the run:



Click **OK** to close the dialog.

NOTE: When a run all is canceled, the steps performed prior to the cancelation will not be undone.

4. When the run all is completed, a **Perform All Errors Dialog** will be displayed indicating any errors that occurred during the run:



Expand the tree nodes in order to identify the errors that occurred. If no errors occurred, a message will be displayed indicating that no errors occurred.

5. Click **OK** to close the dialog.

3.9 Diagnostic Display Panel

The **Diagnostic Display Panel**, an example of which is shown in Figure 15, displays diagnostics as selected by the user via subpanels of the **Estimation Steps Panel**. The diagnostics that can be displayed are described with the subpanels. Also, a general diagnostic display panel framework is described in Section 3.2.4.3.

Some diagnostics can require a significant amount of time draw. Furthermore, it will need to be redrawn whenever the **Diagnostic Display Panel** is resized. To prevent a slowdown in the software resulting from spending too much time rendering displays, a **Dispose Button** is included in the upper left corner of the panel for all diagnostics to display. Click on the button to clear the panel.

NOTE: The chart displayed in the ***Diagnostic Display Panel*** *will not change until another diagnostic is selected to be displayed or the* ***Dispose Button*** *is clicked.*

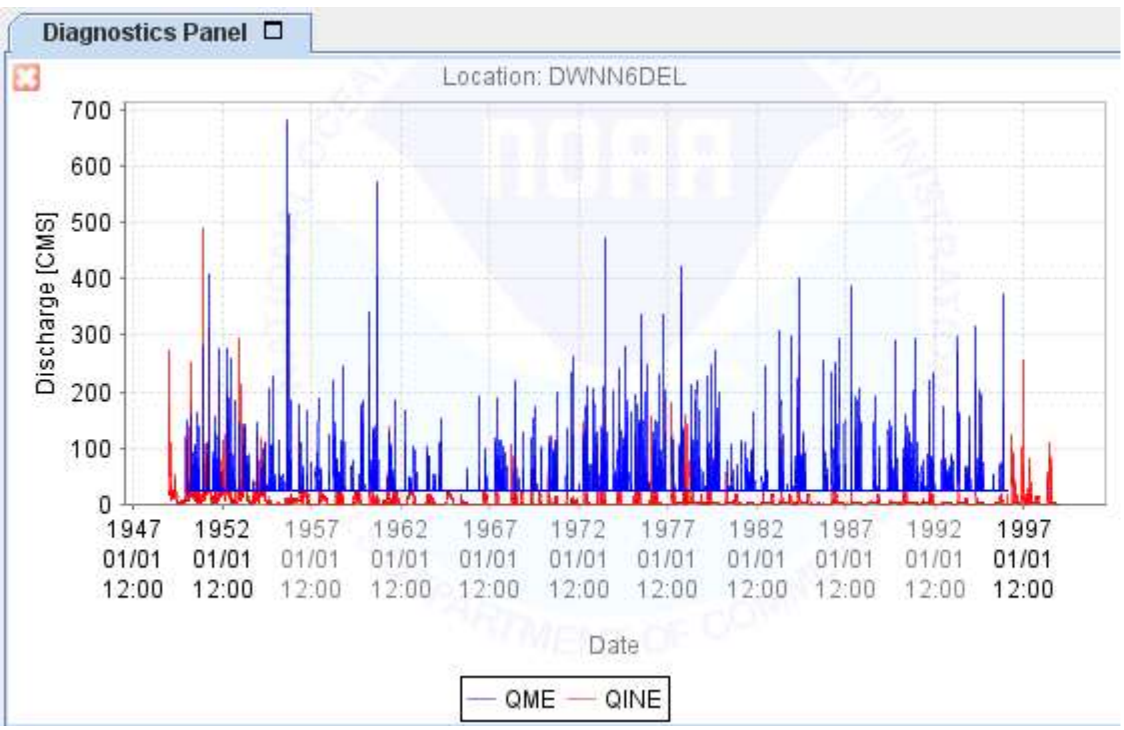


Figure 15 : The **Diagnostics Display Panel**

3.9.1 Components

- **Dispose Button**: Click on this button to dispose of the current diagnostics. The button is only visible if a diagnostic is currently displayed.

4 EnsPost Operational Reference Manual

4.1 Overview

EnsPost corrects hydrologic forecasts in real-time for hydrologic uncertainty using parameters estimated from the EnsPostPE application. EnsPost has three different methods to apply the correction (referred to as Error Models).

This section of the manual describes how to use the EnsPost software. It is recommended that users read Section prior to configuring the module and refer to other sections as needed while using the software. It is run via a Module file which is then added to an existing streamflow ensemble generating workflow.

4.2 Getting Started

The EnsPost is used to post process a streamflow ensemble. This section provides basic background material pertinent to the understanding of the EnsPost software and how to configure it. It explains:

1. Inputs to EnsPost.
2. How to configure the EnsPost module.

4.2.1 EnsPost Model Adapter

Before using the EnsPost Model Adapter, a few setup steps must be completed (See *EnsPostConfigurationGuide* for installation instructions).

4.2.2 Description

The EnsPost model adapter executes the EnsPost within a CHPS workflow. The EnsPost post-processes an ensemble forecast accounting for sources of uncertainty not already accounted for in the input ensemble. It requires as input the following:

- an ensemble of forecast streamflow time series
- a current observed streamflow value

Based on the input combined with parameters calibrated prior to execution (See Section 3 for instructions how to run the parameter estimator), EnsPost generates a post-processed forecast ensemble, with each member in the input ensemble being used to generate a single member of the post-processed ensemble.

EnsPost is a modified version of the standard AWIPS EnsPost (ens_post) software.

4.2.3 Model Parameters

The calibrated parameters used by EnsPost are contained within one tgz file underneath a directory pointed to by the module config file as a run file property. Within the .tgz file, there are 26 parameter files and one directory per location.

4.2.4 Model Time series

Time Series Type	**Model Expected Units**	**Time Step**	**Input or Output**	**Missing Values Allowed**	**Required [Yes or No]**
Observed streamflow time series with sufficient data to compute the current observed value at time T0	As calibrated**	6 or 24-hours	Input	No*	Yes
Forecast ensemble streamflow time series starting one time step after T0	As calibrated**	6 or 24-hours	Input	No	Yes
Ensemble streamflow time series	As calibrated**	Same as input forecast ensemble	Output	No	Yes

* EnsPost requires the current observed value in the time step at which the parameters were calibrated (typically 24 hrs). As such, the observed streamflow time series provided as input will be aggregated to the appropriate time step by EnsPost and the current observed value will be that aggregated over the period ending at time T0.
Hence, it must not include missing values during that aggregation period.

** The units of measurement for the exported time series *must* match the units used to calibrate the EnsPost parameters, usually metric. The model adapter does *not* convert any units.
The ensemble streamflow time series output by the model adapter will have the same header information (location id, parameter id, start time, end time, etc) as the deterministic streamflow forecast time series provided as input, except that it will be given the ensemble id of "HEFSENSPOST".

4.2.5 Notes on Configuration

Run File Properties

The EnsPost model adapter uses specific properties configured within the exportRunFileActivity in a module configuration file and output to the run_info.xml file.
The following properties are used (required parameters are marked). By default, EnsPost will use the location ID and parameter ID of the input streamflow ensemble to construct the name of the estimated parameters file. The optional parameters can be set to override the default values.

Property Name	**Required [Yes or No]**	**Description / Example**
errorModel	Yes	Specify the ErrorModel for EnsPost to use. Valid options are ER0, ERD, ERS. For example: **<string key="errorModel" value="ERS"/>**
parameterDir	Yes	Points to where the tar/gzipped up parameters are stored. This is not optional. By default, it'll point to the ENS_POST_ROOT_DIR global property value but can point anywhere. For example: **<string key="parameterDir" value="Models/hefsEnsPostModelAdapter/parameters"/>**
parameterFile	No	This will allow you to specify the name of the estimated parameters .tgz file. The default format of the parameters file is: <LocationId>.<ParameterId>.enspost.parameters.tgz. For example: **<string key="parameterFile" value="HUNP1ESP.QINE.enspost.parameters.tgz"/>**
peLocationID	No	This allows you to specify the location ID used in the estimated parameters. For example: **<string key="peLocationID" value="HUNP1ESP"/>**
peParameterID	No	This allows you to specify the parameter ID used in the estimated parameters. For example: **<string key="peParameterID" value="QINE"/>**

5 REFERENCES

Brown, J. D., and D.-J. Seo, 2012: Evaluation of a nonparametric post-processor for bias correction and uncertainty estimation of hydrologic predictions. Hydrological Processes, doi:10.1002/hyp.9263

Bogner K, and F. Pappenberger 2011: Multiscale error analysis, correction, and predictive uncertainty estimation in a flood forecasting system, Water Resources Research, W07524, DOI: 10.1029/2010WR009137.

Chen, S.-T., and P.-S. Yu, 2007: Real-time probabilistic forecasting of flood stages, Journal of Hydrology, 340 (1–2), 63–77.

Hantush, M.M., and L. Kalin, 2008: Stochastic residual-error analysis for estimating hydrologic model predictive uncertainty, Journal of Hydrologic Engineering, 13(7):585-596.

Krzysztofowicz, R., 1999: Bayesian Theory of Probabilistic Forecasting Via Deterministic Hydrologic Model, Water Resources Research, 35(9), 2739-2750.

Montanari, A., and A. Brath, 2004: A stochastic approach for assessing the uncertainty of rainfall-runoff simulations, Water Resources Research, 40, W01106, doi:10.1029/2003WR002540.

Montanari, A., and G. Grossi, 2008: Estimating the uncertainty of hydrological forecasts: A statistical approach, Water Resources Research, 44, W00B08, doi:10.1029/2008WR006897.

Regonda et al., 2012: Short-term Ensemble Streamflow Forecasting Using Operationally-Produced Single-valued Streamflow Forecasts - A Hydrologic Model Output Statistics (HMOS) Approach (in preparation)

Seo, D.-J., H. Herr, and J. Schaake, 2006: A statistical post-processor for accounting of hydrologic uncertainty in short-range ensemble streamflow prediction, Hydrological Earth System Science Discussions, 3, 1987-2035.

Todini, E., 2008: A model conditional processor to assess predictive uncertainty in flood forecasting, International Journal of River Basin Management, 6(2), 123–137.